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Subject: Full proposal for a new COST Action:
SWIMMING OF FISH AND IMPLICATIONS FOR MIGRATION AND AQUACULTURE (FITFISH)

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National Coordinator: [*]

Domain Committee: Food and Agriculture

[*] Will be completed by the COST Office

DRAFT
MEMORANDUM OF UNDERSTANDING
For the implementation of a European Concerted Research Action designated as

COST Action

SWIMMING OF FISH AND IMPLICATIONS FOR MIGRATION AND AQUACULTURE (FITFISH)

The signatories 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 299/06 "Rules and Procedures for Implementing COST Actions", or in any new document amending or replacing it, the contents of which the Signatories are fully aware of.

2. The main objective of the Action is [*]

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 [*] Euro [*] million in [*] prices.

4. The Memorandum of Understanding will take effect on being signed by at least five Signatories.

5. The Memorandum of Understanding will remain in force for a period of 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.

[*] Will be completed by the COST Office

A. ABSTRACT & KEYWORDS

A.1 ABSTRACT

The study of swimming of fish is essential for our understanding of the interplay between migration, growth and reproduction in wild fish but also has considerable interest for fish in aquaculture. The main objective of FITFISH is to develop a research network in which fish swimming in the wild and in aquaculture is studied for the first time under a multidisciplinary perspective. Scientists from various disciplines will work together under the umbrella of swimming exercise. FITFISH will provide the ground for technological breakthroughs (e.g. more accurate monitoring of migrant fish; design of exercise-“friendly” fish farming facilities), for establishing swimming as an essential factor determining welfare and for demonstrating that swimming can benefit quality production. By providing this knowledge FITFISH will have a societal (economic and cultural) impact in areas such as environmental and fisheries policy, industrial activity in aquaculture and even human health. FITFISH will add value to independent, nationally funded research activities by providing the means to exchange information, promote industrial activities and influence policies at a European level in a new common forum. Activities in FITFISH also include the training and exchange of early stage researchers in the area to create future leaders with a true multidisciplinary vision.

A.2 Keywords

Swimming exercise, Fish migration, Aquaculture, Early stage research training, Knowledge and technology transfer

B. BACKGROUND

B.1 General background

When one asks a child “What does a fish do?”, the child will answer “Swim!”. Swimming is an integral aspect of the life history of many fish species in the aquatic environment. Teleost fish show a great variety of locomotor strategies that are linked to their feeding behaviour, predator avoidance, environmental (e.g. light, temperature, salinity, depth, etc.) preferences, social and reproductive behaviours, etc. The most dramatic examples of locomotor strategies can be found among those species that undergo long and lengthy reproductive and feeding migrations, such as salmonids, thunniforms and anguillids. From an organismal point of view, swimming is a behaviour that occurs in intimate relation to other biological processes that fish experience throughout their life cycle, such as early development, growth, metabolic status, gonadal development and maturation, etc. (Palstra and Planas, 2013). Therefore, it is fair to state that swimming is a behaviour in fish that is intimately linked to their ability to develop, survive, grow and successfully reproduce in the natural environment. Consequently, swimming is a natural characteristic of fish behaviour that

constitutes a determinant of fitness, either viewed from the classical Darwinian perspective of fitness or, more directly, from physical fitness.

Fishing pressure and global climate changes are affecting population size and structure, reproductive capacity and behaviour of wild fish. In contrast, the demand of fish for human consumption or feed manufacturing is steadily increasing. Aquaculture, i.e. the production of fish under controlled conditions, should provide an answer to this need and, therefore, domestication efforts have rapidly intensified for a number of species. However, fish in aquaculture often cannot display their normal swimming behaviour due to excessive culture densities or insufficient flow streams in their holding facilities and, consequently, they may not experience the physiological benefits that swimming entitles their wild counterparts. This situation of reduced swimming exercise in captive fish has been suggested to result in fish that have reduced fitness (both physical and reproductive), which affects both production quantity and quality. Fish with reduced fitness may exhibit reduced grow, survival and flesh quality in the final product that is destined for the consumer.

A research network on the topic of fish swimming has already been created and organized by the Proposer through several recent actions that include: 1) a highly successful first international workshop on the topic entitled “FITFISH: Workshop on the Swimming Physiology of Fish”, held in Barcelona in July of 2010 (http://www.ub.edu/fitfish2010); 2) a special issue on the physiology of swimming of fish in the journal Fish Physiology and Biochemistry (June 2011: http://link.springer.com/journal/10695/37/2/page/1) and 3) an edited book entitled “Swimming Physiology of Fish. Towards using exercise to farm a fit fish in sustainable aquaculture” (2013: http://www.springer.com/life+sciences/animal+sciences/book/978-3-642-31048-5). This forum has established the grounds for a valuable platform in which researchers with interests in fish swimming physiology can be brought together and participate. Research related to fish swimming is currently receiving renewed and increasing attention because optimal exercise may have beneficial effects of major importance for the success and survival of migratory fish species as well as for aquaculture applications that include: 1) Improved feeding efficiency, growth rates and skeletal muscle mass; 2) Changes in muscle composition leading to higher flesh quality; 3) Increased survival by increased robustness or fitness; 4) Increased welfare by lowered stress; 5) Stimulation of immune status, and 6) Reproduction control.

The FITFISH COST Action will further develop this recently created research network to gain integral knowledge on swimming of fish under a truly multidisciplinary perspective. The Action will gather biologists and biochemists studying the swimming of fish from gene to behaviour and back, but also ecologists, bio-designers and engineers. FITFISH will attract industrial partners and policy makers to embark on new European perspectives for applying the new insights on facilitated fish migration, for integrating swimming-induced exercise in aquaculture for farming a fitter fish and for setting directions for policy and future studies. Mechanistic studies on the beneficial effects of exercise in fish have only recently been initiated and only at a national level. No projects at a European scale have yet been initiated on this topic and this COST network will contribute to initiating such projects within EU Framework Programmes and other European fora.

As a COST Action, FITFISH will create a comprehensive synthesis of research, industry and policy activities that deal directly or indirectly with fish swimming. COST offers the best framework for this action because

support for a new, innovative, interdisciplinary and broad scientific network will be requested. Specifically, this COST Action will support the continuation of this network by funding 1) regular meetings where all the different stakeholders will participate in evaluating existing knowledge, transfer of knowledge among stakeholders and decision making bodies, 2) training and exchange of early researchers and 3) dissemination activities.

B.2 Current state of knowledge

Swimming of fish has received considerable attention during the last few decades. However, from a physiological point of view, research on fish swimming has traditionally focused on the energetics or economy of swimming, on the utilization of energy reserves during and after swimming and on the cardiovascular adaptations to swimming. More recently, nationally funded research initiatives in the European area have emerged to evaluate the underlying causes for the improved robustness or fitness of fish subjected to swimming-induced exercise and to evaluate the beneficial “secondary” effects of swimming (e.g. improved growth, improved flesh quality, improved survival, controlled reproduction, etc.). Examples are the improvement of Atlantic salmon smolt robustness to reduce losses in sea by development of exercise regimes in Norway, and Yellowtail kingfish quality improvement by swimming exercise in The Netherlands (ref. E3). Furthermore, research activities related to tracking migratory species throughout their reproductive and/or feeding migrations are shedding light onto the survival and/or success of migrating fish particularly in the face of changing environmental conditions. An increasing number of, mostly national, studies are currently involved in assessing various methods for stimulating swimming behaviour in fish (e.g. water flow manipulation, induction of optomotor response, development and use of robot fish, etc.) and their potential application in aquaculture. The timing of the Action will be excellent for the international integration of results coming from these studies.

The FITFISH COST Action will, for the first time, provide a framework in which a number of different aspects related to fish swimming (i.e. from natural migratory fish to improving swimming behaviour in aquaculture) are all brought together, evaluated and discussed. The action will bring together three groups of stakeholders: 1) scientists working on swimming and migration, feeding and nutrition, skeletal and muscle development, health, welfare, immunology, reproduction and product quality (flesh quality, taste etc). 2) industry people, fish farmers who look to improve production through issues such as welfare, vets working with disease control and welfare, nutrition companies, fish marketing and SMEs developing technologies to exercise aquaculture fish, 3) Policy makers, that can promote fish migration improvement measures and the aquaculture of fish through research and governance. These stakeholders will be brought together for the first time to focus their individual expertise on the effects of swimming and to give a multidisciplinary vision on the benefits of swimming on the organism to provide improved products or an improved ecosystem. This Action will be instrumental in establishing this topic as a discipline and also in creating a new generation of researchers by training young scientists under a multidisciplinary program in a truly collaborative environment.

B.3 Reasons for the Action

The FITFISH COST Action will be needed to consolidate and continue the development and activities of the already established network of expert researchers in the area of fish swimming. Independently, the different expert researchers have, in addition to creating significant advances in the scientific knowledge in this area, already begun to establish and pursue contacts and collaborations with the aquaculture industrial sector and end users. This COST Action will provide the necessary environment to expand these collaborations, identify common and specific industrial problems and propose solutions. Due to its broad, multidisciplinary nature and due to the different levels of stakeholders involved (researchers, industry, policy makers, etc.), this COST Action is aimed at addressing economical/societal needs, as well as at creating scientific/technological advances. The Action is expected to contribute to the improvement of fish migration and implementation of exercise in aquaculture; which will provide new jobs to designers, engineers, consultants and researchers; which will increase quantity and quality of production for European farmers, and which will address fish welfare concerns of fish in the natural aquatic ecosystems as well as on the farms. The success of this COST Action will be ensured by applying indicators of maximal progress, such as the publication and public dissemination of the outcomes of stakeholders meetings; the standardization and shared use of methods for inducing and monitoring swimming of fish; the successful transfer of knowledge to the industry and policy makers as assessed by the establishment of novel, environmentally-sound swimming-induction methods in the aquaculture industry, and by the introduction of policies that will protect the safe migratory behaviour of fish.

B.4 Complementarity with other research programmes

Liaison and interaction with other research programmes are described under E3. None of the mentioned research programmes duplicates the aims of this COST Action, none of these research programmes unites a multidisciplinary group of scientists studying the swimming of fish, industrial partners and policy makers to gain integral knowledge on swimming of fish for farming a fitter fish, improving fish migration opportunities and setting directions for policy and future studies.

C. OBJECTIVES AND BENEFITS

C.1 Aim

The aim of the Action is to strengthen and improve our knowledge on swimming of fish and its applicability in improving the status of wild and farmed fish by bringing together research and industrial partners with policy makers. More specifically: To build capacity among the high-quality scientific research community involved in studying the swimming of fish and its implications for migration and aquaculture, to support its integration; to leverage national research investments; to address an issue of global relevance and to increase the impact of science and technology on policy makers, regulatory bodies and national decision makers; To promote participation of young talents and next generation leaders in science and technology, promote

working opportunities for early stage researchers, provide gender balance, and foster inter-disciplinarity; To promote participation of COST Members Countries and Cooperating States and encourage European regions to develop their capacities and strengthen excellence in this area; By means of organising meetings, short term scientific missions, training schools, dissemination and publications. The synthesis of knowledge on swimming of fish in the natural environment that will be created with this COST Action will allow to assess environmental/anthropomorphic influences like the impact of climate change on the behaviour of natural migratory fish populations and the effectiveness of migration mitigation measures. Furthermore, this Action will determine the basis to classify induced swimming as a natural, non-invasive and economical approach to improve growth, flesh quality as well as welfare of fish in aquaculture: A fit fish for a concerned consumer. Besides the scientific and societal benefits of improved fish migration and fish welfare, as well as improved fish filet quality and human health, significant technological breakthroughs can be expected because of the multidisciplinary nature of this COST Action: Development of technologies to induce swimming; Development of technologies to measure swimming performance (swim-tunnels, individual video tracking, etc); Exercise raceway design; Fish migration bypass design; Improved telemetry and tracking software; Development of tailor made feeds for athletic fish; Development of robotic fish to lead the school.

C.2 Objectives

1) Evaluation of existing knowledge on the functional mechanisms behind beneficial exercise effects and identification of gaps in our knowledge for targeting future research efforts; 2) Evaluation of existing fish migration data, monitoring methodology for tracking migrant fish and bypass design, and the use of expertise within the platform to identify potential improvements; 3) The use of expertise within the platform to evaluate existing swimming data, to identify gaps in our knowledge for targeting future research efforts and to design optimal exercise protocols for specific species and conditions; 4) The use of expertise within the platform for the development of new technology; 5) The use of the established research network to search for collaborative project opportunities; 6) Set-up communication with policy makers (aquaculture, fisheries, environment and food authorities) for setting directions for policy and future studies; 7) Set-up communication with the industry to explore the feasibility for application of exercise enhancement in aquaculture; 8) Transfer of knowledge between scientists, industry and policy makers; 9) The use of the multidisciplinary nature of the platform to disseminate scientific reviews; 10) Construction of a website; 11) Training of early stage researchers; and 12) Exchange of early stage researchers.

C.3 How networking within the Action will yield the objectives?

Means to achieve the aims: 1) Meetings of the Management Committee (MC); 2) Meetings of five working groups (WGs); 3) Annual workshops linked to international conferences; 4) Early stage researcher training programme; and 5) Early stage researcher exchange programme and Short-Term Scientific Missions.

C.4 Potential impact of the Action

The FITFISH Action will not only advance our knowledge by integrative new insights on the basic swimming physiology of fish but will also lead to improved understanding of how fish migrate and how that changes in the light of a changing environment; improved fish welfare and production, and technological breakthroughs (ref. to section B). Dissemination and communication of new scientific knowledge and technological development to the scientific community, the European aquaculture and fish food industry, policy makers and society will represent an important objective of this Action. Finally, this Action will serve as a training ground for early stage researchers providing them with opportunities to acquire competence that will greatly contribute to their career development thereby creating the future capacity to further develop the explored fields of research. A breakdown of benefits into the scientific, industrial, policy, pan-European and global dimensions is provided for.

C.5 Target groups/end users

1) Aquaculture industry at large, involved through producing a fit fish; 2) Fish food industry at large; involved through custom made diets for fit fish; 3) Recently established companies and initiatives to establish new companies that develop swimming technologies for studying fit fish or producing them; 4) International, national and regional governmental bodies, involved through making policy in aquaculture, fisheries and ecology; 5) Environmental agencies, involved through development of tracking devices and improved fish bypasses; 6) Scientists, involved through training, exchange, new research lines and opportunities to apply for funding. Representatives of all stakeholder groups were involved in the FitFish workshop as preceding step and/or the preparation of this proposal itself.

D. SCIENTIFIC PROGRAMME

D.1 Scientific focus

Most important research tasks: The FITFISH COST Action represents the first attempt to study swimming of fish from a truly multidisciplinary perspective by bringing together experts in the field, industrial partners and policy makers. This Action is innovative because joint efforts from researchers covering a wide range of disciplines will create an unprecedented framework of knowledge and expertise in the area of fish swimming. This Action aims, therefore, at improving basic and practical knowledge on the importance of swimming for fish in the wild and in aquaculture. One important aspect of this Action is to provide novel technological solutions to study, monitor and implement swimming of fish. An additional aspect of this Action is to consolidate, transfer and disseminate the knowledge acquired by training, scientific exchange and dissemination activities.

Work plan: The different activities or research tasks that will be covered by this Action will be performed by

five different Working Groups (WG), whose activities are detailed in the following section. The research tasks that will be performed are the following: 1) Meetings. This Action will initiate its activities at a MC kick-off meeting. MC meetings will be held annually to evaluate progress, draft progress reports and plan future activities. WG meetings will also be held annually, right after the MC meeting; 2) Workshops. Annual workshops will be organized in an open format in which speakers, participating or not in this Action, will contribute with state-of-the-art talks of general interest for the Action; 3) Scientific exchange programme. The exchange and mobility of especially early stage researchers will be made possible by establishing a programme with annual calls that will be evaluated by members of the MC; 4) Training programme. A training programme involving theoretical and practical training schools for early stage researchers will be organized. Theoretical courses will be offered annually whereas practical courses will be offered every two years; 5) Dissemination activities. The outcome of the various research tasks will be summarized and publicized in reviews, and perhaps book chapters and edited books in the topic of the Action. Furthermore, technical documents describing the technological breakthroughs achieved by the action and recommendations for their implementation will be prepared, as well as more educational, informative documents meant for the general public but also for policy makers. A public website that will contain all aspects related to the Action, including all the dissemination documents and material prepared during the course of the Action, will be constructed.

Human and technical means to achieve the objectives: The FITFISH Action is composed of a formidable team of experts from the academic, basic and applied research and industrial fields that have demonstrable expertise in the different research tasks that will be performed. Furthermore, this team of experts belong to leading governmental, public and private institutions that will be able to provide the necessary means to achieve the technological objectives set by this Action.

D.2 Scientific work plan - methods and means

Scientific work plan and methods of the Action: Swimming, as an integral part of the behaviour of fish, is a multi-faceted process that is key to the animal's ability to feed, grow, reproduce, interact with other individuals and explore different environments; that is, to perform in their own ecological niches. In this complex process, there are a number of gaps in our knowledge that prevent us from fully understanding the physiological adaptations that swimming confers or the behaviour of migrating fish. In addition, information is needed on how swimming in wild populations of fish can be affected by environmental changes and also on how swimming in farmed fish is affected or disturbed by current and upcoming farming practices. Given this scenario, this Action aims at establishing a working network of scientists that will provide up-to-date information on swimming of wild and farmed fish, on the implementation of technological approaches to better study fish swimming both in the wild and in aquaculture and that will formulate and recommend solutions to solve or improve various aspects related to swimming of fish. Furthermore, this Action aims at training a cohort of early stage researchers in theoretical and practical aspects related to swimming.

Working Groups, their objectives and what they will achieve: The methods that will be used in this Action involve the identification and development of five different aspects related to swimming of fish that will

support the Action's objectives, each of which constituting a Working Group (WG):

WG1. FUNCTIONAL MECHANISMS BEHIND THE BENEFICIAL EFFECTS OF SWIMMING: *Objectives:* Given that swimming is an intrinsic characteristic of fish behaviour, swimming-induced activity in fish, like in mammals, may confer beneficial physiological effects. Fish are known for their great capacity for aerobic, sustained swimming and anaerobic, burst swimming that are accomplished through the activation of red and white skeletal muscle. One of the well-known beneficial effects of swimming is the stimulation of growth. Other potential beneficial effects of swimming include the control of reproduction, modulation of the immune response and reduced stress. However, limited information is available on the mechanism(s) by which exercise potentiates growth or affects the reproductive, immune and stress systems in fish. The aim of this WG is to evaluate existing knowledge on the functional mechanisms behind the beneficial effects of swimming and identify gaps in knowledge in this area for targeting future research efforts. *Tasks:* 1) Organization of WG meetings and workshops to provide the state-of-the-art in a broad range of physiological responses to swimming; 2) Discussion of integrated knowledge on the physiological effects of swimming and evaluation of high-throughput biochemical and molecular techniques for its study; 3) Publication of reviews or book chapters summarizing the information synthesized in this WG. *Achievements:* 1) Synthesis of knowledge on the functional mechanisms responsible for the beneficial effects of swimming-induced exercise in fish; 2) Establishment of a network of scientists that will pursue the common goal of understanding further the physiological effects of swimming, that will assess the technical appropriateness of various research approaches and that will elaborate research proposals to fund its objectives; 3) Publication of summarized information on the beneficial physiological effects of swimming in the form of reviews in scientific journals, chapters in edited books and technical documents.

WG2. FISH MIGRATION: *Objectives:* Migratory fish species form an essential part of the ecological quality of surface waters. The strong human influence on many water bodies in Europe has had detrimental effects on populations of migratory fish species, which have declined or even disappeared in many cases. Measures to restore migration have, until now, a strong ad hoc, or case-study character. Therefore there is need for a profound, integrative scientific approach, leading to a framework for analysing migration and the design of effective measures. Moreover, existing knowledge is often scattered, or poorly accessible, because it is not published as scientific peer-reviewed papers. The aim of this WG is to exchange and integrate knowledge among scientists and experts involved in the field and to develop a research agenda aimed at generating new knowledge in the fields of 1) monitoring fish behaviour in real-life situations, using a range of well-known and high-tech techniques, 2) experimental approaches in which the effect of disturbing cues on behaviour and physiology of individual fishes is investigated, and 3) modelling the effects of mitigating measures on population dynamics. *Tasks:* 1) Organization of WG meetings and workshops to exchange the latest state-of-the-art knowledge on fish migration to develop a comprehensive framework on what drives fish migration covering all relevant disciplines; 2) Development of a research agenda aimed at a) monitoring of fish behaviour in real-life situations and in large mesocosm-scale settings, using a range of well-known and also high-tech techniques, ranging from fyke-netting, telemetry, and observations with underwater cameras and DIDSON imaging; b) an experimental approach in which the effect of a number of disturbing cues can be studied on the level of behaviour and physiology of individual fishes; and c) modelling the effects of mitigating measures on the population dynamics; 3) Developing a toolbox to design effective and efficient

options for mitigation measures aimed at ecological water quality, but also at other uses of the water bodies, such as hydropower and navigation. Such a toolbox would include one or more decision algorithms, but potentially also new technological solutions; 4) Reporting the synthesized and newly-developed information from the WG in review papers written by the partners in the project and presented at the Action's meetings and international scientific symposiums. *Achievements:* 1) An international network of fish migration experts that has international scientific, but also societal impact; 2) A research agenda aimed at generating new scientific and applied knowledge on fish migration; 3) A toolbox for the design and evaluation of effective and efficient mitigation measures for fish migration; 4) A comprehensive framework on what drives fish migration, reported in a review paper written by the partners in the project and presented at international scientific symposiums.

WG3. EXERCISE IN AQUACULTURE: *Objectives:* In aquaculture, fish robustness eludes to the ability of the fish to thrive in the face of any perturbation during production, such as pathogens, handling and environmental stress, rapid growth and development, etc. Currently, exercise training by swimming is the only available strategy for industrial use, in front of other strategies involving genetic improvement and optimization of environmental conditions. Sustained exercise training by swimming is an effective proactive preventive strategy to improve robustness of farmed fish. Furthermore, swimming training may affect specific quality characteristics such as external appearance and fillet texture that have potential to be integrated in product labelling of exercised fish. However, to date, induced swimming has had little application in commercial aquaculture operations. The aim of this WG is to gather expertise to evaluate existing swimming data, to identify gaps in our knowledge for targeting future research efforts and to design optimal swimming protocols for specific species and conditions. *Tasks:* 1) Organization of WG meetings and workshops to provide the state-of-the-art in exercise training by swimming in farmed fish; 2) Discussion on available methods for measuring water current in land and sea-based systems, for monitoring physiological and immunological improvements (ref WG 1) and swimming activity (ref WG 2), and for the manipulation of swimming behaviour in production systems; 3) Publication of reviews, book chapters or technical documents synthesizing the information recollected in this WG. *Achievements:* 1) Establishment of a network of scientists, industries and policy makers that will address issues related to the improvement of farming conditions by inducing swimming in farmed fish; 2) Technological advances in the form of (a) improved protocols for measuring water current, (b) improved knowledge on monitoring swimming activity in production systems, (c) improved overview of informative biochemical markers and tests applicable for industrial use, (d) improved tank design for improved water flow, (e) novel and effective systems to motivate swimming behaviour in fish by stimulation of the optomotor response and by the use of robotic fish; 3) Identification of the optimal exercise protocol for each of the species under consideration in view of existing infrastructures.

WG4. TRANSFER OF KNOWLEDGE TO END USERS: *Objectives:* The successful transfer of knowledge between scientists and industry, on one hand, and policy makers, on the other hand, is a crucial determinant of the success of this Action. Measures will be put into place to facilitate this transfer of knowledge through all communication channels available. Furthermore, evaluation measures for the successful transfer of knowledge to end users will also be implemented. *Tasks:* 1) Organization of bilateral meetings between Action participants and industry representatives and policy makers; 2) Drafting of technical manuals on swimming in

migratory fish and on the application of swimming in aquaculture targeted to stakeholders in the industry and in regulatory and policy centres; 3) Monitoring of the use of transferred information by the industry and regulatory and policy centres. *Achievements:* 1) Establishment of an information channel between scientists and the industrial sector, on one hand, and policy makers, on the other hand; 2) Publication of technical manuals on swimming in migratory fish and on the application of swimming in aquaculture; 3) Implementation of evaluation measures (indicators) of the successful transfer of knowledge to end users: welfare, physiological, technological and/or economic indicators of success in the industrial sector and indicators of regulatory progress towards changes in farming practices and product labelling in aquaculture.

WG5. TRAINING OF EARLY STAGE RESEARCHERS: *Objectives:* This WG will be specifically aimed at the training of early stage researchers. Their current expertise, skills and interests will be assessed as well as the competences that will be useful to be acquired in order to occupy a future niche in this newly emerging research field. On basis of this information, theoretical and practical training schools will be designed. Experts in the field will be invited to give shape to these schools. Besides those, early stage researchers will be given the opportunities to present their work orally and receive feedback during WG meetings as well as presenting in more official settings at the Action's workshops and congresses that they are linked to. Finally, especially early stage researchers will have the chance to apply for funding of short term research missions by yearly calls that will be beneficial to enhance their mobility, to work in a different scientific environment, to create and strengthen collaborations, and to stimulate the flow of information and expertise. *Tasks:* 1) Assess competences to be acquired of potential participants; 2) Organise annual theoretical training schools; 3) Organise bi-annual practical training schools; 4) Training oral dissemination skills; 5) Arrange short term research missions for early stage researchers by yearly calls. *Achievements:* Early stage researchers with the potential to apply for personal post-doctoral research grants (e.g. Marie Curie) and occupy future research niches in the novel field.

E. ORGANISATION

E.1 Coordination and organisation

General organisation and implementation of this COST Action will be performed according to the "Rules for Participation in and Implementation of COST Activities" (COST 4112/13) and management according to "COST Action Management" (COST 4114/13). This COST action will have two levels of organisation: 1) Management Committee (MC) representing 5 COST countries with each 1-2 representatives including the Chair (the Proposer) and Vice-Chair; 2) Working Groups (WGs) consisting of a Working Group coordinator, expert Action members and early stage researchers. Because WG coordinators are also part of the MC, there is no need for a third level of organisation, such as a Core Group to create communication between members of the MC and WG coordinators. Such matters will be discussed during the MC meetings including invitees whenever specific additional expertise is required. 21 milestones are foreseen as indicated in the timetable (ref. F).

@1 The MC: 1) remains ultimately in charge of the Action, whilst it may arrange for particular support to it or its Chair in their tasks; 2) maintains the MoU; 3) decides upon all budget relevant questions; 4) devises the general Action strategy; 5) manages the organisation of the Action activities: a) sets up an “e-group” communication system; b) sets up a WG reporting system and discusses WG progress; c) ensures the organisation and follow up on regular MC and WG meetings; d) follows up on timely communication of milestones; e) manages knowledge and IPR and assistance to the preparation of its exploitation; f) follows up on the dissemination and publication activities; g) ensures efficient information flow within the project and follows up on information provided; h) provides any assistance needed to fulfil dedicated tasks; i) is the main conflict solving organ; @2 Five Working Groups (WGs) will be created on basis of the defined aims as specified under D2 and E2.

How the coordination of national research will be implemented: The results of research that is carried out in and financed by the participating countries of this Action in the fields of functional mechanisms behind beneficial effects of swimming, fish migration and exercise in aquaculture (WGs 1-3) will be presented at workshops, and discussed and integrated at WG meetings. National research activities and results will be inventoried by the appropriate WG coordinators and communicated within the MC. Strategies will be developed for the most efficient ways of transferring this knowledge to end users (WG4) and train early stage researchers in each of these fields separately and with special attention for their integration and multidisciplinarity (WG5). Therewith knowledge will be integrated and made applicable for the industry and policy makers.

Action specific website: An action specific website will be launched that will keep visitors updated on the progress and achievements of the COST action. Updating the website will be performed most regularly (max. every three months). The website will be kept active until at least 5 years after official termination of the COST Action and will remain to be linked to spin-off projects and published dissemination that will result from the COST action. Social media (Facebook, LinkedIn, Twitter, YouTube) will be used to draw attention to news updates of the Action and link to the Action’s website. A press release will launch the Action for the regional, national and international press.

E.2 Working Groups

Five Working Groups (WGs) will be created on basis of the defined objectives (C2): WG1: objectives: specifically 1, and generally 4 and 5; WG2: objectives: specifically 2, and generally 4 and 5; WG3: objectives: specifically 3, and generally 4 and 5; WG4: objectives: 6, 7, 8, 9 and 10; WG5: objectives: 11 and 12. WGs consist of a WG coordinator, expert members and early stage researchers aiming at a total size of 15-35 researchers per WG. WGs will work together to identify transversal or common objectives. WG meetings are aimed at the specific topic and expertise of each WG, the workshops will have a more integrative nature. WG coordinators and the MC will steer and evaluate WG integration in the MC meetings.

E.3 Liaison and interaction with other research programmes

Liaisons and interaction with three COST actions, five other appropriate European research programmes and six national programmes (one Dutch and five Norwegian) that the MC members are involved in are foreseen. Interactions between this COST Action and other COST Actions, appropriate European and national research programmes will be organised by inviting target people of those Actions and programmes to WG meetings and annual workshops of this Action, as well as the other way around by attending relevant meetings of those Actions and programmes by members of this Action. This will cause an exchange of information that may lead to the initiation of joint activities like seminars or publications.

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 considerably involve early-stage researchers. This item will also be placed as a standard item on all MC agendas.

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 considerably involve early-stage researchers. This item will also be placed as a standard item on all MC agendas.

The MC of this COST Action aspires that about 40% of the persons involved will be women. In accordance with Articles 2 and 3 of the Treaty of Amsterdam (1997) and other EU policy directives (COM [96] 67 final) and report (EUR 20022), the MC is committed to incorporating gender principles throughout the various elements of the Action. To this end, every effort will be made to ensure that activities contribute to the promotion of gender equality wherever possible. It will be actively attempted to compensate for the inequality in gender balance by increasing the female percentage of potential participants from the current 27.4% to 40%.

Involvement of early-stage researchers: One of the major objectives of this Action is to train early-stage researchers in the newly emerging fields of exercise physiology, ecology and behaviour of fish: Research fields that the Action will further develop thereby providing them with a future in science aimed at innovations in aquaculture, fish migration and even biomedical studies. WG 5 is specifically aimed at training and exchange of early stage researchers and provides information flow between the early stage researchers, their supervisors and promoters, and the WG coordinator (‘think tank’). Annual practical and theoretical training schools will be organised and short term scientific missions will be made possible that specifically aim for early stage researchers. The WG meetings and workshops will provide a platform for the presentation of their work. These will be organised as satellite events of international congresses such as meetings of the European and World Aquaculture Societies and the International Congress on the Biology of Fish making it easier for early stage researchers to attend these and present their work for the scientific community among others through an annual conference grant system. Spin off projects, including Marie Curie initiatives, will

further help them in securing a position. The proposer of the Action is still an early stage researcher himself and as such he will be Chair of the MC and Dutch national delegate. Because of its own status as early stage researcher and receiver of personal grants like a Marie Curie IEF and Marie Curie reintegration grant, he will be WG coordinator on WG5 Training of early stage researchers. Therewith this Action adheres to the COST Strategy for Early Stage Researchers (COST doc. 295/09).

F. TIMETABLE

The duration of the Action is **four** years and schedules as follows:

Y1 M1: MC kick-off meeting; WG meetings 1; *M1*: successful MC meeting 1; *M2*: WG establishments; *M3*: successful WG meetings 1; *D1*: website

Y1 M3: annual workshop 1; theoretical training school 1; *M4*: successful workshop 1; *M5*: successful theoretical training school 1

Y1 M11: MC progress meeting and drafting 1st annual progress report; WG meetings 2; *M6*: successful MC meeting 2; *M7*: successful WG meetings 2

Y1 M12: *D2*: 1st annual progress report

Y2 M17: annual workshop 2; theoretical training school 2; practical training school 1; *M8*: successful workshop 2; *M9*: successful theoretical training school 2; *M10*: successful practical training school 1

Y2 M23: MC progress meeting and drafting 2nd annual progress report; WG meetings 3; *M11*: successful MC meeting 3; *M12*: successful WG meetings 3

Y2 M24: *D3*: 2nd annual progress report

Y3 M31: annual workshop 3; theoretical training school 3; practical training school 2; *M13*: successful workshop 3; *M14*: successful theoretical training school 3; *M15*: successful practical training school 2

Y3 M35: MC progress meeting and drafting 3rd annual progress report; WG meetings 4; *M16*: successful MC meeting 4; *M17*: successful WG meetings 4

Y3 M36: *D4*: 3rd annual progress report

Y4 M46: annual workshop 4; theoretical training school 4; MC end meeting: drafting final report and future perspectives; *M18*: successful workshop 4; *M19*: successful theoretical training school 4; *M20*: successful MC end meeting 5

Y4 M48: *M21*: successful termination of the Action; *D5*: final report

(**Y**= year; **M**= month; *M*= milestone; *D*= deliverable)

G. ECONOMIC DIMENSION

The following 5 COST countries have actively participated in the preparation of the Action or otherwise indicated their interest: France, Netherlands, Norway, Spain, United Kingdom. On the basis of national estimates, the economic dimension of the activities to be carried out under the Action has been estimated at 20 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.

The following fourteen COST Countries have actively participated in the preparation of the Action or otherwise indicated their interest: **Spain, Netherlands, Norway, France, UK, Italy, Sweden, Denmark, Germany, Belgium, Austria, Finland, Greece and Portugal**. Additionally, eight non-COST countries have indicated their interest including **Canada, Japan, the US, Australia, New Zealand, Brazil, Chile and Argentina**. On the basis of national estimates, the economic dimension of the activities to be carried out under the Action has been estimated at **20** Million € for the total duration of the Action. This amount has been calculated from the formula “nr of countries X 4 Mio EUR” as stated by the “preliminary editorial instructions for Full Proposal” and on basis of the five countries that will immediately support this 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. Calculations have been based on 8 scientists representing 5 COST countries in the MC of which 5 also have a role as WG coordinator. Furthermore, active roles are expected of at least two representatives for each of the other seventeen countries. These 42 scientists will manage and coordinate 19 meetings, workshops and schools, and write four annual reports and at least two review papers. For workshops and schools, keynote speakers and session-chairs will be invited, as well as for MC meetings when appropriate. Finally, one representative per COST Country will be reimbursed for attendance at DC plenary meetings. Furthermore, person years are estimated on basis of the preparation and attendance at meetings, research stays and local organisation of meetings. Additional expenses include a website, organisation costs of meetings and schools (max. 10k euros per meeting support to local organiser), travel and subsistence costs as reimbursements for stays of entitled COST participants and invitees as determined by the MC, reimbursements for short research stays (max 2.5k euros for a max of 3 months; at least 4 per yr) and the experimental infrastructure for the practical training schools.

H. DISSEMINATION PLAN

H.1 Who?

The target audiences are particularly the end users of the gained integral knowledge that will be disseminated by the Action. The aquaculture industry including farmers, designers, engineers, processors and traders will benefit three fold: faster production, higher production, higher quality production. Additionally, the aquaculture industry will benefit from an increased appreciation that the public has for the improved welfare conditions of the fish. The general public itself will benefit by eating healthier and higher quality fish: a fit fish for the concerned consumer. The fish food industry will benefit by producing new custom made feeds for athletic fishes. Recently established SME companies and initiatives to establish new companies that develop swimming technologies will benefit from the newly obtained insights. Environmental agencies will benefit from newly designed tracking devices and improved fish bypasses. International, national and regional governmental bodies will benefit from reaching the aims that the Action has: increased capacity and integration of the scientific community, the training of young talents and next generation leaders in science and technology, and the creation of job opportunities. Moreover, this Action will provide them with a sustainable alternative for non-sustainable fisheries and with measures to boost the natural stocks. The scientists themselves benefit from training opportunities, the exchange of people and ideas, the development of new research lines and opportunities to apply for funding. Additionally, both scientists and funding organisations will benefit from the implementation of new insights as gained by the Action into running projects and near future projects. And finally, the fish will benefit through increased health and welfare conditions, resulting in lower disease occurrence and mortality.

H.2 What?

Internal dissemination methods consist of an “e-group” communication system, WG meetings, a WG reporting system and meetings of the MC.

The scientific community is of course very welcome to participate in the Action. The annual workshops and training schools are excellent tools for information exchange. These will have a more open character, also industry and policy makers will be invited to such occasions. By linking the workshops as satellite events to international congresses an even broader international community is reached.

Furthermore, the writing of at least two review papers is anticipated for: one on the opportunities for exercise implementation in aquaculture (e.g. in the journal Aquaculture) and one on strengthening the scientific base for fish migration (e.g. in the journal Reviews in Fish Biology and Fisheries). Popular scientific papers will be written and interviews will be given aimed at the national and international magazines (e.g. Aquaculture Europe, H_2O Magazine) to increase the accessibility.

The Action will recommend species specific guidelines on exercise implementation in aquaculture and on fish migration including identification of knowledge gaps. It will be attempted as much as possible to come up

with ready-to-apply recommendations for the aquaculture industry, environmental agencies and governments.

The general public is reached by the website, press release(s) and Social media (Facebook. LinkedIn, YouTube, Twitter).

H.3 How?

The annual reports function as communication tool among the members of the Action as well as with the EU. The annual workshops and training schools will be used for information exchange also towards industry and policy makers, and, by linking the workshops as satellite events to international congresses, towards an even broader international community. At least two review papers and popular scientific papers will be written and interviews will be given to increase the accessibility to the Action and its results for the scientific community. Species specific guidelines will reach the aquaculture industry, environmental agencies and governments directly. The website, press release(s) and Social media will be used to reach the public.

The described dissemination plan will form the framework of a first draft dissemination plan that will be updated in each annual report as resulting from MC meetings. The dissemination plan will be updated in line with the evolution of the newly emerging research field, new developments within the Action, its results, and through evaluation of feedback coming from the target audiences.

Part II - Additional Information (This part will not be element of the MoU)

Part II-A . LIST OF EXPERTS

Total number of participants 8
Gender balance: female 1 of 8 (12.50%)

COST Participants

ES - Spain

Dr Neil DUNCAN IRTA Aquaculture [Proposal Participant] [Potential MC Member] [WG Member] Expertise: FA - Aquaculture	Dr Josep PLANAS Universitat de Barcelona Departament de Fisiologia [Proposal Participant] [Potential MC Member] [WG Member] Expertise: FA - fish physiology

FR - France

Dr Marie-Laure BéGOUT Ifremer [Proposal Participant] [Potential MC Member] [WG Member] Expertise: FA - Aquaculture	

NL - Netherlands

Dr Arjan PALSTRA IMARES Aquaculture [Proposal Participant] [Potential MC Member] [WG Member] Expertise: FA - Aquaculture; fish physiology; fish migration	Dr Leo NAGELKERKE Wageningen University Aquaculture and Fisheries [Proposal Participant] [Potential MC Member] [WG Member] Expertise: FA - Fish migration

NO - Norway

Dr Harald TAKLE Nofima [Proposal Participant] [Potential MC Member] [WG Member] Expertise: FA - Aquaculture	

UK - United Kingdom

Dr Sunil KADRI
AquaInnovation
[Proposal Participant] [Potential MC Member] [WG Member]

Expertise: FA - Aquaculture	Dr Simon MACKENZIE University of Stirling Marine Biotechnology Institute of Aquaculture [Proposal Participant] [Potential MC Member] [WG Member] Expertise: FA - Aquaculture

Non-COST Participants

None

European Commission Participants

None

European Bodies Participants

None

Part II-B. HISTORY OF THE PROPOSAL

The proposer of the Action Dr. AP Palstra had been studying the swimming physiology of European eels as PhD student and as post-doc over the period 2001-2008 at the Leiden University and its spin-off company ZFscreens in The Netherlands. Fascinated by the semelparous reproductive migration of European eels of 6,000-km to the Sargasso Sea without eating, he studied the swimming performance and the exercise effects on maturation in swim-tunnels and a swimming carrousel. He and Prof. JV Planas were then awarded with a Marie Curie IEF grant to identify swimming induced metabolic and hormonal switches that trigger reproduction at the University of Barcelona in Spain (REPRO-SWIM; 2008-2010) which became an EC success story. Besides studying specifically the exercise effects on reproduction in rainbow trout, more and more the overall physiological benefits of exercise in fish were considered now also using zebrafish as a model. In 2010, Palstra and Planas organised the international workshop FITFISH in Barcelona (http://www.ub.edu/fitfish2010) with the intention to bring together a multidisciplinary group of scientists using exercise models, industrial partners and policy makers. The objective was to gain integral knowledge on swimming of fish for farming a fitter fish and setting directions for policy and future studies. The workshop lead to a special issue of Fish Physiology and Biochemistry (June 2011: http://link.springer.com/journal/10695/37/2/page/1) and a book published by Springer: “Swimming Physiology of Fish. Towards using exercise to farm a fit fish in sustainable aquaculture” (September 2012: http://www.springer.com/life+sciences/animal+sciences/book/978-3-642-31048-5). The workshop was immediately followed by the first symposium on the Swimming Physiology of Fish as part of the 9th International Congress on the Biology of Fish. In the meantime also the second symposium has been organised as part of 10ICBF in Madison (US) and the third symposium will be part of 11ICBF in Edinburgh (UK) in 2014. Palstra has now a position as senior researcher and project leader at The Institute for Marine Resources and Ecosystem Studies (IMARES), part of Wageningen University & Research Centre, where he is involved in projects on swimming exercise, fish migration and the implementation of exercise in aquaculture by among others a personal EU Marie Curie reintegration grant N° 303500: “Zebrafish as Novel Model for Exercise-enhanced Skeletal and Cardiac Muscle Growth and Immune Functioning (SWIMFIT)”; a national project funded by Dutch Ministry of economic affairs and the European Fisheries Fund: “Yellowtail kingfish quality improvement by swimming exercise, nutrition and genetics” (KINGKONG), and the

EU FP7 project:"Improving European aquaculture by advancing selective breeding to the next level for the six main finfish species (FISHBOOST)". Together and with a large European network Palstra and Planas elaborate on their collaborative efforts in this application for a COST Action to study fish swimming in the wild and in aquaculture for the first time under a multidisciplinary perspective for establishing swimming as an essential factor determining welfare in fish and for demonstrating that swimming can benefit quality production.

Part II-C. PRELIMINARY WORK PROGRAMME

n.a.

Part II-D. RECENT PUBLICATIONS

Scientific self-portrait of the Proposer/Chair and Vice-chair of this Action by publications related to the topic of the Action over the last 5 years (other MC member is also indicated in bold):

Editing activities special issue and book

1. **Palstra AP**, **Planas JV** (2013) Swimming Physiology of Fish: Towards using exercise to farm a fit fish in sustainable aquaculture. Heidelberg: Springer, pp. 429.
2. **Palstra AP**, **Planas JV** (2011) Special issue: Fish under exercise: The FitFish Workshop on the Swimming Physiology of Fish. Issue 2 – June 2011.

Peer reviewed papers in scientific journals

1. Burgerhout, E., Tudorache, C., Brittijn, S.A., **Palstra, A.P.**, Dirks, R.P.H., van den Thillart, G.E.E.J.M. (2013) Schooling reduces
energy consumption in swimming male European eels, *Anguilla anguilla* L. Journal of Experimental Marine Biology and Ecology 448: 66-71. (IF 2.40)
2. **Palstra, A.P.**, Beltran, S., Burgerhout, E., Brittijn, S.A., Magnoni, L.J., Henkel, C.V., Jansen, H.J., van den Thillart, G.E.E.J.M., Spaink, H.P., and **Planas, J.V.** (2013) Deep RNA sequencing of the skeletal muscle transcriptome in swimming fish. PLoS ONE 8(1): e53171 (IF 4.35)
3. Anteneh, W., Getahun, A., Dejen, E., Sibbing, F., **Nagelkerke, L.**, de Graaf, M., Wudneh, T., Vijverberg, J., **Palstra, A.P.** (2012) Spawning migrations of the endemic Labeobarbus (Cyprinidae, Teleostei) species of Lake Tana, Ethiopia: status and threats. Journal of Fish Biology 81: 750–765 (IF 1.23)
4. Magnoni, L.J., Vraskou, Y., **Palstra, A.P.**, **Planas, J.V.** (2012) Effects of agonist-induced activation of AMP-activated protein kinase (AMPK) on glucose uptake by brown trout (*Salmo trutta*) myotubes. PLoS ONE 7(2): e31219 (IF 4.35)
5. **Palstra, A.P.**, Guerrero M-A., de Laak G., Klein Breteler J.P.G., van den Thillart G.E.E.J.M. (2011)

Temporal progression in migratory status and sexual maturation in European silver eels during downstream migration. Fish Physiology and Biochemistry 37: 285-296 (IF 1.61)

6. **Palstra, A.P.**, **Planas, J.V.** (2011) Fish under exercise. Fish Physiology and Biochemistry 37: 259-272 (IF 1.61)
7. **Palstra, A.P.**, Tudorache, C., Rovira, M., Brittijn, B., Burgerhout, E., van den Thillart, G.E.E.J.M., Spaink, H.P., **Planas, J.V.** (2010) Establishing zebrafish (*Danio rerio*) as a novel exercise model: Swimming economy, swimming-enhanced growth and regulation of muscle growth marker gene expression. PLoS ONE 5(12): e14483 (IF 4.35)
8. **Palstra, A.P.**, Crespo, D., van den Thillart, G.E.E.J.M., **Planas, J.V.** (2010) Saving energy to fuel exercise: swimming suppresses oocyte development and down-regulates ovarian transcriptomic response of rainbow trout *Oncorhynchus mykiss*. American Journal of Physiology - Regulatory, Integrative and Comparative Physiology 299: R486-R499 (IF 3.27)
9. **Palstra, A.P.**, van den Thillart, G. (2010) Swimming physiology of eels: energetic costs and effects on sexual maturation and reproduction. Fish Physiology and Biochemistry 36: 297–322 (IF 1.61)
10. **Palstra, A.P.**, Schnabel, D., Nieveen, M., Spaink, H., van den Thillart, G. (2010) Swimming suppresses hepatic vitellogenesis in European silver eel as shown by quantitative RT-PCR of the estrogen receptor 1, vitellogenin1 and vitellogenin2 in the liver. Reproductive Biology and Endocrinology 8: 27 (IF 2.63)
11. van Ginneken, V., **Palstra, A.**, Leonards, P., Nieveen, M., van den Berg, H., Flik, G., Spannings, T., Niemantsverdriet, P., van den Thillart, G., Murk, T. (2009) PCBs and the energy costs of migration in European silver eel (*Anguilla anguilla*). Aquatic Toxicology 92: 213-220 (IF 3.87)
12. **Palstra, A.P.**, Schnabel, D., Nieveen, M.C., Spaink, H.P., van den Thillart, G.E.E.J.M. (2008) Male silver eels mature by swimming. BMC Physiology 8: 14 (IF 2.12)
13. **Palstra, A.**, van Ginneken, V., van den Thillart, G. (2008) Cost of transport and optimal swimming speeds in farmed and wild European silver eels (*Anguilla anguilla*). Comparative Biochemistry and Physiology A 151: 37-44 (IF 1.71)

Scientific book chapters

1. Magnoni, L.J., Márquez-Ruiz, P., **Palstra, A.P.**, **Planas, J.V.** (2013) Physiological consequences of swimming-induced activity in trout. In: Trout (Polakoff and Moon eds.)
2. **Palstra, A.P.**, Schaaf, M., **Planas, J.V.** (2013) Exercise physiology of zebrafish: Swimming effects on skeletal and cardiac muscle growth, on the immune system and the involvement of the stress axis. In: Swimming Physiology of Fish: Towards using exercise to farm a fit fish in sustainable aquaculture (Palstra AP and Planas JV eds.), Heidelberg: Springer, pp. 323-344.
3. **Planas, J.V.**, Martín-Pérez, M., Magnoni, L.J., Blasco, J., Ibarz, A., Fernandez-Borras, J., **Palstra, A.P.** (2013) Transcriptomic and Proteomic Response of Skeletal Muscle to Swimming-Induced Exercise in Fish. In: Swimming Physiology of Fish: Towards using exercise to farm a fit fish in sustainable aquaculture (Palstra AP and Planas JV eds.), Heidelberg: Springer, pp. 237-256.
4. Hayashida, K., Fukaya, K., **Palstra, A.P.**, Ueda, H. (2013) Salmonid reproductive migration and effects on sexual maturation. In: Swimming Physiology of Fish: Towards using exercise to farm a fit fish in

sustainable aquaculture (Palstra AP and Planas JV eds.), Heidelberg: Springer, pp. 3-18.
5. **Palstra, A.P.**, Schnabel, D., Nieveen, M., Spaink, H.P., van den Thillart, G.E.E.J.M. (2012) Sexual maturity and swimming in male silver eels. In: Current research in animal physiology (Lamoureux, V. ed.), Oakville: Apple Academic Press Inc, pp. 203-207.
6. Van Ginneken, V., Bruijs, M., Cordes, M., Leonards, P., **Palstra, A.**, Murk, T., van den Berg, H., van den Thillart, G. (2009) The effect of PCBs on spawning migration of European eels (*Anguilla anguilla* L.). In: Spawning migration of European eel. Reproduction index, a useful tool for conservation management (G. van den Thillart, S. Dufour and C. Rankin eds.), Heidelberg: Springer, pp. 365-386.
7. van den Thillart, G., van Ginneken, V., **Palstra, A.** (2009) Energy requirements of European eel for Trans Atlantic spawning migration. In: Spawning migration of European eel. Reproduction index, a useful tool for conservation management" (G. van den Thillart, S. Dufour and C. Rankin eds.), Heidelberg: Springer, pp. 179-199.
8. **Palstra, A.**, van Ginneken, V., van den Thillart, G. (2009) Effect of swimming on silvering and maturation. In: Spawning migration of European eel. Reproduction index, a useful tool for conservation management (G. van den Thillart, S. Dufour and C. Rankin eds.), Heidelberg: Springer, pp. 229-251.

Part II-E. FURTHER REMARKS

@ C.4 Potential impact of the Action

Breakdown of benefits into the scientific, industrial, policy, pan-European and global dimensions

Scientific dimension

This Action will agglutinate the different independent R&D activities that are currently being performed in this area. This will allow the identification of common areas or ground on fish swimming that will be best addressed through multidisciplinary actions such as this one, i.e. use knowledge from wild fish and its migration to optimize exercise programs for aquaculture purposes. A benefit of this Action will be to improve the coordination and effectiveness of research activities at a European level. Therefore, this Action will provide an added value to nationally funded research initiatives and increase the transfer of knowledge and information among these various initiatives and their participants through scientific meetings, workshops, training schools and exchange visits. Fundamental and applied research knowledge gaps will be identified in this Action and will result in project proposals that will compete for funding the closing of these gaps. A new generation of researchers will be taught the ins and outs of the described research fields and will be trained to lead and develop such projects in the future. The concerted Action will therewith lead to a viable and necessary research line of swimming exercise fish biologists that will create opportunities for implementation of exercise in aquaculture for farming fit fish and for improved migration of fish in nature.

Industrial dimension

The range of activities covered by this Action will have a significant impact on the industrial sector, both in terms of increased production and the development of technological breakthroughs. Through the continuation of existing and the development of new tight contacts with the industrial sector this Action will contribute to increase the productivity and competitiveness of the European aquaculture sector by establishing swimming as a natural, clean and non-invasive approach to increase growth, flesh quality and welfare in cultured fish. This will lead to the development of a differentiated product (fit fish) that could be targeted to specific markets: a healthy fish for a concerned consumer. This Action will also be important for the development of technological breakthroughs that will include the development of highly efficient systems for manipulating and improving the swimming behaviour of farmed fish (i.e. tank and raceway design for improved water flows, development of systems that trigger the optomotor response of farmed fish as well as of robotic fish that can lead a school of fish, etc.), improved tracking devices for monitoring the behaviour of migratory fish, etc. This Action will provide the necessary framework for research and industrial partners to successfully engage in fruitful collaborative activities aimed at achieving these technological goals. This Action will have clear impact on the direct economic revenue of the participating SMEs. Secondly, participating in RTD increases the knowledge base within each company which is of utmost importance in order to have skilled and motivated employees. By essential innovations, this Action may secure the existing employment at the SMEs. Thirdly, the willingness and successful implementation of new production methods and strategies increases the product (fish), reputation and thus the competiveness of the SMEs. Finally, by solving specific bottlenecks and by improving the margins the SMEs improve their financial standing and by that the possibility to get loans for necessary investments, i.e. to increase the production or to endure the financial crisis in Europe.

Policy dimension

The creation of a working network of experts in this Action that include leading research and industrial partners as well as policy makers will be instrumental for establishing directions to assess the performance of fish in the wild as well as in aquaculture. MC members of this Action all have a good network of national and European policy makers that will be invited to meetings when appropriate. First, data from fish migration studies and the physiological assessment of migrating fish generated in this Action will influence decision makers regarding environmental and conservation issues. Second, data from performance studies of fish subjected to induced swimming in experimental and industrial facilities that will be compiled, synthesized and analysed in this Action will be used by decision makers to establish monitoring tests for fish performance assessment in aquaculture (most importantly for health and welfare purposes), to allow the creation of specific labels that identify fish raised under swimming conditions (fit fish), etc.

Pan-European dimension

The purpose of this Action is to create a strong network on the topic by bringing together leading European research and industrial partners as well as policy makers (at the national and European levels) that will work collectively towards a common European goal. This goal will apply equally to all European countries involved and will avoid the concentration of resources or research efforts in certain parts of Europe or on specific species. In order to achieve this, this Action will include a large number of participants in relevant EU projects (E.3) covering most of the member states.

Global dimension

In a world of a global economy, it will be crucial to expand the borders of this Action and establish contacts and collaborations with researchers, industry and policy making bodies outside of Europe. Participants in this Action already have established collaborations in the topic of fish swimming with non-European countries such as Canada, Japan, the US, Australia, New Zealand, Brazil, Chile and Argentina. Existing contacts will be strengthened and new contacts with other non-European countries will be established by inviting them to participate in research and collaborative activities in this Action.

Industry support

From several companies, mostly SMEs, we have already been collecting support letters that express their intention to participate in this COST Action and that shows that they value its aims, in particular those that stimulate the role of the industry in the newly emerging research field of swimming physiology and its applications for the implementation of exercise in aquaculture and the improvement of fish migration opportunities. These companies are:

AquaInnovation (UK, Sunil Kadri) – among others Optoswim technology www.optoswim.com and www.aquainnovation.com

Loligo Systems ApS (Denmark, Jannik Herskin) - products for aquatic animal ecophysiology and behavior analysis www.loligosystems.com

Nutreco Skretting (Norway/Netherlands, Arjen Roem) - production and supply of feed for farmed fish and shrimp www.skretting.com

SILT (Netherlands, Kees Kloet) – yellowtail kingfish RAS farmer http://www.silt.nl/

ATKB (Netherlands, Igor Spierts) – consultancy for water, soil and ecology http://www.at-kb.nl/

Wanningen Water Consult (Netherlands, Herman Wanningen) – consultancy on water management, ecology and communication http://www.wanningenwaterconsult.nl/en

Visadvies (Netherlands, Jan Kemper) - research, development and evaluation of fish migration facilities, study of fish behavior, monitoring and assessment of fish stocks, development of fisheries management plans and rehabilitation plans, and habitat evaluation http://www.visadvies.nl/english

Grontmij (Netherlands, Carlo Rutjes) – among others aquatic ecology http://www.grontmij.nl

The COST Action will also invite global farming companies including Marine Harvest, Grieg Seafood and Leroy Seafood Group and aquaculture associations (e.g. FHF and FEAP) as these are already supporting projects involving fish exercise.

@ E.3 Liaison and interaction with other research programmes

Liaisons and interaction with three COST actions, five other appropriate European research programmes and six national programmes (one Dutch and five Norwegian) that the MC members are involved in are foreseen.

For possible liaisons and interaction with other COST Actions, the following COST actions are appropriate:

- FA COST Action 867 “Welfare of fish in European aquaculture” http://www.cost.eu/domains_actions/fa/Actions/867
- FA COST Action 1004 “Conservation Physiology of Marine Fishes” http://www.cost.eu/domains_actions/fa/Actions/FA1004
- FA COST Action 1205 “Assessing and improving the quality of aquatic animal gametes to enhance aquatic resources” http://www.cost.eu/domains_actions/fa/Actions/FA1205

(Action 867 has ended and the knowledge that it has raised can be applied to assess a role for exercise in stimulating welfare of fish in aquaculture. A first step was already made during the round table discussion that ended the FITFISH workshop.)

IMARES, the research institute of the Proposer, is participating in COST actions FA867 and 1004. Communication lines with the Chairs of all these Actions have been established. Several COST Action 867 members attended the FITFISH workshop that was organised in July 2010 in Barcelona. Recently contact was established by attending the 1004 COST meeting at SEB2013 in July 2013 in Valencia, Spain. Email communication is ongoing on the mutual interests of exercise effects on sexual maturation and gamete quality with the coordinator of Action 1205.

Liaisons and interaction with five other appropriate European research programmes and six national programmes (one Dutch and five Norwegian) that the MC members are involved in are foreseen:

- the recently granted European Community’s Seventh Framework Programme (FP7/2007-2013) project: “Improving European aquaculture by advancing selective breeding to the next level for the six main finfish species (FISHBOOST)”;
- the recently granted European Community’s Seventh Framework Programme (FP7/2007-2013) project: “Enhancing the European aquaculture production by removing production bottlenecks of emerging species, producing new products and accessing new markets (DIVERSIFY)”;
- European Community’s Seventh Framework Programme FP7-KBBE-2010-4: “A new integrative framework for the study of fish welfare based on the concepts of allostasis, appraisal and coping styles (COPEWELL)”
- European Community’s Seventh Framework Programme (FP7/2007-2013) project with grant agreement no 262336: “Aquaculture Infrastructures for Excellence in European Fish Research (AQUAEXCEL)”
- European Community’s Seventh Framework Programme (FP7/2007-2013) Marie Curie reintegration grant N° 303500: “Zebrafish as Novel Model for Exercise-enhanced Skeletal and Cardiac Muscle

Growth and Immune Functioning (SWIMFIT)";

- a national project funded by Dutch Ministry of economic affairs and the European Fisheries Fund: "Yellowtail kingfish quality improvement by swimming exercise, nutrition and genetics (KINGKONG)";
- a national project funded by the Research Council of Norway and The Norwegian Seafood Research Fund with grant agreement N° 225218/E40 and N° 900870, respectively: "Improving Atlantic salmon smolt robustness to reduce losses in sea by development of screening tests, exercise regimes and markers (FITSMOLT)";
- a national project funded by the Research Council of Norway with grant agreement N° 216177/E40: "Studies of virulence mechanisms and host responses to infection with piscine myocarditis virus (PMCV)";
- a national project funded by MABIT with grant agreement N° AF0067: "Cardiac health as risk factor for mortality upon slaughter in North of Norway";
- a national project funded by the Research Council of Norway, Marine Harvest, Grieg Seafood and Smola Klekkeri and Settefish with grant agreement N° 217502: "Optimized postsmolt: a shift in paradigm for the Norwegian salmon industry (OPP)";
- a national project funded by the Regional Research Fund of Norway and SalmoBreed with grant agreement N° 224758: "Improved cardiac health of farmed salmon by breeding and exercise in sea";

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

Steps will be taken to ensure that none of the activities within the programme contributes to gender inequality or aggravates existing gender inequality. The Action will lead to new employment opportunities requiring skilled personnel. Based on the increasing fractions of female students in several university degree programmes, including engineering degrees, the number of females trained and skilled for land-based production systems for aquatic organisms and fish migration improvement will be increasing in the future.

@IIA The current FITFISH network and list 2 potential participants

The FITFISH network currently consists of 95 participants representing universities, companies and research institutes from 22 countries. 75 participants represent 14 European countries: Spain (27); Netherlands (10); Norway (8); France (7); UK (5); Italy (4); Sweden (4); Denmark (3); Germany (2); Belgium (1); Austria (1), Finland (1), Greece (1) and Portugal (1). Additionally, the FITFISH network has non-European collaborative contacts in Canada (4), Japan (4), the US (3), Australia (2), New Zealand (2) Brazil (1), Chile (1) and Argentina (1). These experts have participated in the FITFISH workshop and have addressed their interest in this Action. Their names, affiliations and email addresses are provided in list 2. Besides, Palstra moderates the LinkedIn group FitFish counting 127 members, for a large part additional participants than those that visited the workshop.

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