ParaFishControl

Project News

Issue 2

Advanced Tools and Research Strategies for Parasite Control in European Farmed Fish

29 PARTNERS

13 COUNTRIES

WWW.PARAFISHCONTROL.EU

September 2017

ParaFishControl is a €7.8 million European Union-funded Horizon 2020 project addressing the challenges of parasitic disease prevention and management, aimed at assuring the sustainability and competitiveness of the European aquaculture industry.

WELCOME TO THE SECOND NEWSLETTER OF THE PARAFISHCONTROL PROJECT

IN THIS ISSUE:

Enteromyxum leei ©Ariadna Sitjà-Bobadilla

Welcome from the Project Coordinator

Welcome to the second newsletter of the ParaFishControl project which showcases the many different activities and outputs we are working on across the whole project. We have had a very busy year, with many tasks engaging the consortium across the eight work packages; some results are already published and have been presented at different events, and even a patent is on its way. Communication among partners, with the interchange of samples, methods, reactives and students has been essential for many activities. We have also started to bridge the gap between science and the aquaculture industry through invaluable industry events, bringing stakeholders from science and industry together, highlighting the role of partnerships and collaborative approaches to instigate real and profound change. It is really exciting to witness evidence based science being recognised as being applicable by industry and subsequently being used in a real world setting with affirmative and measurable results.

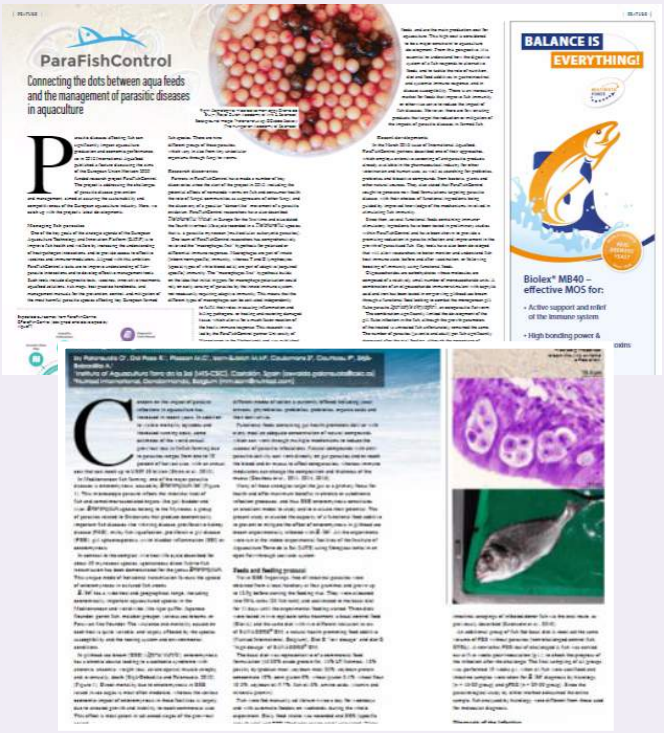
Dr Ariadna Sitjà-Bobadilla

The Fish Pathology group of the Institute of Aquaculture Torre de la Sal at Consejo Superior de Investigaciones Científicas (IATS-CSIC). From left to right: Dr Ariadna Sitjà-Bobadilla (Head of the group and ParaFishControl coordinator), Dr Itziar Estensoro (PostDoc), Raquel del Pozo (Technician), Dr Oswaldo Palenzuela (Senior Researcher), Amparo Picard (PhD student working on ParaFishControl) and Dr Carla Piazzon (PostDoc).

Featuring ParaFishControl Research

Connecting the dots between aqua feeds and the management of parasitic diseases in aquaculture

Feature article about ParaFishControl in the "International Aquafeed" magazine, June edition 2017, pages 14-19. To read the full article, please visit: bit.ly/2udSqcO



Functional feed additives

Feature article about the collaborative research of ParaFishControl and Nutriad International on functional feed additives in the "International Aquafeed" magazine, July edition 2017, pages 14-19. To read the full article, please visit: bit.ly/2tPSBuZ

Project News

New robot to improve the DNA and RNA extraction process

ParaFishControl partner CSIC has a new handling robot for automation of DNA and RNA extraction. It will be used to compare the gene expression of *Enteromyxum leei*-infected fish versus control fish to decipher the immune response of *Sparus aurata* (part of work package 1), and to detect parasite DNA (*E. leei and E. nucleophila*) for the diagnosis of an infection in samples generated by CSIC and sent by other ParaFishControl partners in work packages 3, 4 and 6.

Technician Raquel del Pozo operating the robot ©CSIC

Collaboration and exchange between partners

ParaFishControl researchers from the University of Copenhagen (KU, Denmark) are currently collaborating with a number of other partners to establish sustainable parasite control methods for European fish farming enterprises.

They are focusing on investigating antiparasitic vaccines as well as natural and environmental compounds to eliminate the white spot disease caused by the parasitic ciliate *Ichthyophthirius multifiliis*. This ongoing study, which also involves the Hungarian Academy of Sciences (MTA, Hungary), is now revealing new possibilities.

In addition, partners from the Centre for Environment, Fisheries and Aquaculture Science (Cefas, UK) are visiting KU to test novel technologies for killing infective stages in the pond water.

In the lab at the University of Copenhagen Dr Azmi Al-Jubury (left), and Tom Hill (right) ©KU

By combining these approaches and methods, the ParaFishControl researchers plan to present solutions for industry within the project period.

Past Events

International Fisheries Symposium - IFS 2016

Phu Quoc, Vietnam, 31 October - 2 November 2016

The symposium took place under the motto "Promoting healthier aquaculture and fisheries for food safety and security", a topic close to the heart of ParaFishControl which was represented by Dr Csaba Székely (MTA).

ParaFishControl partner Dr Csaba Székely (MTA, left) with a colleague ©MTA

Training course on recent advances in fish nutrition research

Benicàssim, Spain, 13-15 June 2017

Research results and conclusions from ParaFishControl, and other EU funded projects like ARRAINA and AQUAEXCEL[2020] were presented at a unique training course on "Fish Nutrition Research: Recent Advances and Perspectives". The course was organised by Prof Jaume Pérez-Sánchez from the Nutrigenomics and Fish Growth Endocrinology Group of the Institute of Aquaculture Torre de la Sal (IATS-CSIC) and was sponsored by the US Soybean Export Council (USSEC).

Course group photo in Benicàssim ©IATS-CSIC

Lectures were held by researchers of IATS-CSIC, Institut national de la recherche agronomique (Dr S Kaushik and Dr G Corraze), Universidad de Las Palmas de Gran Canaria (Prof M Izquierdo and Prof J Afonso), and Sparos Lda (Dr L Conceição). Topics covered a wide range of nutrition-mediated issues: larval nutritional programming, nutrient x genotype interactions, resistance to bacterial and parasite infections, food safety, and long-term consequences of low fish meal/fish oil diets in fish species of interest in aquaculture (rainbow trout, European sea bass, gilthead sea bream). The course was completed with a visit to IATS-CSIC facilities.

The course details are available at: www.nutrigroup-iats.org/ussec

Hungarian Fisheries Scientific Days

Hungary, 14-15 June 2017

The Hungarian ParaFishControl team from MTA took part in the annual Hungarian Fisheries Scientific Days event. The Hungarian version of the ParaFishControl abstract can be found in the programme, and the project poster was displayed in the entrance hall of the congress.

Hungarian Fisheries Scientific Days ©MTA

Health, welfare and productivity: Three good reasons to fight parasitic diseases in aquaculture

Bologna, Italy, 16 June 2017

On invitation of the Italian Society of Fish Pathology (SIPI), a technical-scientific meeting was held, presenting research activities carried out by the University of Udine and the University of Bologna within the ParaFishControl project. The event included an update by researchers from the University of Padua on emerging diseases in Italian trout farms. Attendees included researchers from private and public institutions, vets, technicians, fish farmers, and students. The presentations from the event (in Italian) will be made available on the SIPI website: bit.ly/2xamqVj

18th Fish Immunology / Vaccination Workshop

Wageningen, the Netherlands, 30 April - 4 May 2017

These Wageningen workshops have been organised annually since 1998. The objective of this workshop was to provide participants with advanced knowledge, both theoretical and practical, on the immune system of fish. Workshop participants discussed the latest insights in the evolution of the immune system and, in particular, fish vaccination.

The 19th workshop programme (29 April-3 May 2018) will be announced here: **bit.ly/2jD2VBK**

Group photo of the workshop participants ©Wageningen University

Guided tour to set up the Spanish Day of Aquaculture

Various locations, Spain, June 2017

ParaFishControl partner IATS-CSIC and Andromeda organised a guided tour to the facilities of FrescaMar (part of Andromeda holding) in Burriana (Castellón, Spain). Researchers from CIAL-CSIC and the Francisco de Vitoria University, and top chefs Miguel Barrera from Cal Paradis and Javier García Peña from Sibaritas Klub visited the High School of Hostelry and Tourism in Castellón and IATS facilities. This core group is involved in organising the "Day of Aquaculture" to be held 30 November 2017, in which different scientific and gastronomic activities will be combined, including activities to communicate ParaFishControl to a wider public.

Guided tour to set up the Day of Aquaculture in Spain ©CSIC

18th International Conference on diseases of Fish and Shellfish

Belfast, Northern Ireland, 4-8 September 2017

The 18th International Conference on Diseases of Fish and Shellfish was organised by the European Association of Fish Pathologists (EAFP; bit.ly/2xebY1H).

Four days of exciting presentations in three parallel sessions covered over 200 oral and more than 200 poster presentations, as well as seven specialised workshops (including the ParaFishControl Industry Forum, see page 9).

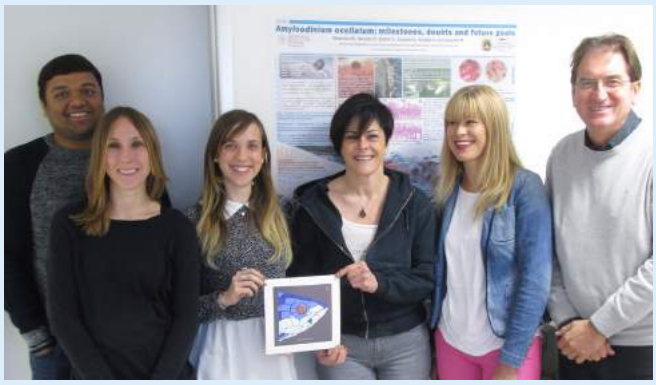
Session topics included: vaccines, nutrition and health, diseases of public concern, sea lice, cleaner fish, parasitological diseases, emerging pathogens, bacterial diseases, viruses, bivalve and crustacean diseases, host-parasite

interaction, fish and shellfish immunity, aquatic animal welfare, immunostimulation, gill diseases, diagnostics, environmental and toxicological diseases, viral myopathies, aquatic animal epidemiology, and salmonid viral diseases.

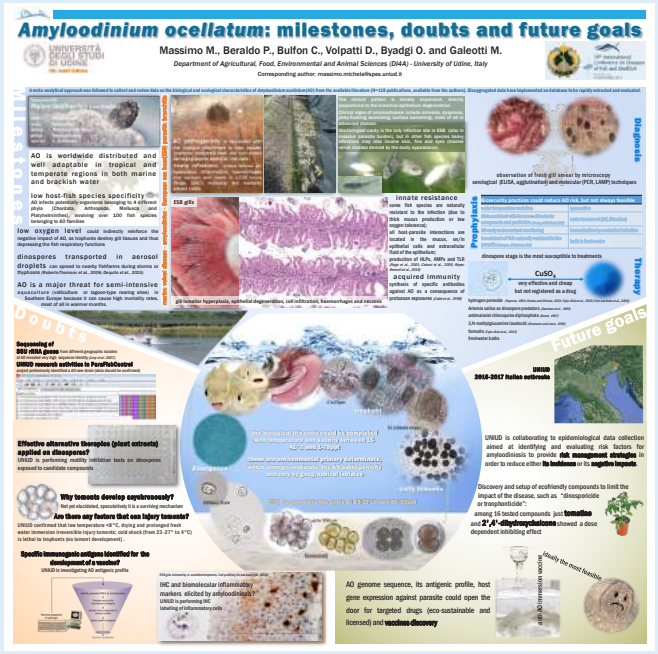
More than 30 members of ParaFishControl attended the conference and contributed over 30 presentations (22 oral and 11 posters).

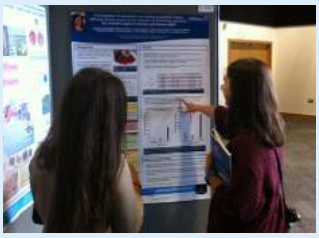
One poster from ParaFishControl member Michela Massimo from the Università degli Studi di Udine (UNIUD) in Italy won the second prize in the poster competition. Congratulations!

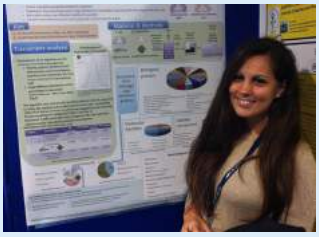
This poster is the result of a meta-analytical approach on *Amyloodinium ocellatum*. Literature revision, also planned in work package 6, was the starting point to generate innovative data aimed at improving our knowledge on this parasite to limit its impacts on aquaculture. In fact, by filling the remaining gaps on the biology and ecology of this protozoan, it might be possible to formulate targeted drugs (eco-friendly and licensed) and develop vaccines, to help achieve ParaFishControl goals.



UNIUD group (top); Michela Massimo's successful poster (below) ©UNIUD







Clockwise from top left: Carolina Fernandez (PhD student, University of Stirling) and Amparo Pichard-Sánchez (PhD student, CSIC) discussing Carolina's ParaFishControl poster, "A comparison of absorption and release properties of three different clinical swaps for the detection of *Paramoeba perurans*, the causative agent of amoebic gill disease"; Project Coordinator Dr Ariadna Sitjà-Bobadilla (CSIC) talking about the road ahead; ParaFishControl Scientific Council members Dr Simon Jones, DFO, Canada (left) and Prof Jerri Bartholomew, Oregon State University, USA (right), with Dr Ariadna Sitjà-Bobadilla (middle); ParaFishControl partner Dr Oswaldo Palenzuela (CSIC) enjoying exciting presentations; and Amparo Pichard-Sánchez (PhD student, IATS-CSIC) presenting her ParaFishControl poster, "Filtering and characterisation of *Enteromyxum* spp. (Myxozoa) transcriptomes from RNAseq data" ©Ariadna Sitjà-Bobadilla and AquaTT

Upcoming Events

Aquaculture Europe 2017

Dubrovnik, Croatia, 17-20 October 2017

'Cooperation for Growth' is the theme for this year's Aquaculture Europe (AE2017) conference in Croatia. Turning policy into growth can be achieved by diminishing competitive forces through common actions using regional cooperation, public-private partnerships and other initiatives that help to reduce conflicts. Increased cooperation between operators may therefore foster positive growth in the European aquaculture sector.

For more information regarding the event, please visit: bit.ly/2upsvPG

Workshop on Securing Fish Health in Wild and Cultured Fish

Copenhagen, Denmark, 25 October 2017

DAFINET (Danish Fish Immunology Research Center & Network) is hosting a one-day workshop on "Securing fish health in wild and cultured fish: from pangas and tilapias via carps to salmonids". It is organised by ParaFishControl partner, the University of Copenhagen, Denmark.

To register and/or submit an abstract please contact Dr Per W Kania (pwk@sund.ku.dk) before 10 October 2017. For more details see: www.parafishcontrol.eu

Industry Corner

To ensure a measurable impact of the ParaFishControl research findings on the aquaculture sector, the effective transfer of new knowledge to different end-users (academia, industry and policy makers) is required, resulting in uptake and application. ParaFishControl has planned and already undertaken activities that will ensure that research findings are shared with a variety of stakeholders such as fish farmers/growers, fish health professionals, agricultural advisors, breeders, scientists working in academia or industry, consumers and policy makers as well as the general public.

ParaFishControl expert consultation on Mediterranean (MED) fish parasites

Barcelona, Spain, 10-11 November 2016

We would like to thank all the Mediterranean Aquaculture industry experts that participated in the workshop for a very interactive, open and productive meeting!

ParaFishControl parasite experts prepared literature reviews on the impact of four of the most important parasites in the Mediterranean mariculture industry, namely *Sparicotyle chrysophrii*, *Enteromyxum leei*, *Ceratothoa oestroides*, and *Amyloodinium ocellatum*.

Experts reviewing the knowledge on parasites in the Mediterranean mariculture industry ©AQUARK

The Centre for Environment, Fisheries and Aquaculture Science (Cefas), together with

CSIC, AQUARK and the ParaFishControl parasite specialists, developed questionnaires to consult industry experts on factors that may increase the risk or protect against infection and disease caused by these parasites. The areas covered by the questionnaire included: disease characteristics, incidence and prevalence; impact of farm characteristics and environmental factors; pathways for parasite introduction; impact of management practices; treatment strategies; and mixed infections.

Experts, including Mediterranean industry fish health managers, veterinarians, fish farmers and research scientists with specialization in these parasites, were then invited to take part in a two-stage consultation process: an online participation (using the questionnaires mentioned above), followed by a workshop in which the outcomes from the online questionnaire were reviewed and discussed. This meeting provided an excellent opportunity for the ParaFishControl project to share information with industry and continue to work towards results that will benefit all those connected with aquaculture as producers or consumers.

The literature reviews and outcomes from the expert consultation are now forming the basis for the design of field studies and will feed into the development of cost effective biosecurity and integrated parasite management strategies. This important collaboration with industry will continue throughout the ParaFishControl project as researchers continue to interact with key stakeholders through epidemiological studies, fish farm visits and economic impact assessments. This will help to develop guidelines for integrated pest management practices to better manage parasitic diseases in Mediterranean mariculture.

Industry stakeholders are invited to join the ParaFishControl LinkedIn Group to follow the progress: www.linkedin.com/groups/8429051

Participants of the expert consultation ©AQUARK

Intense work during the meeting ©AQUARK

The meeting was organised by Ariadna Sitjà-Bobadilla (CSIC) – ParaFishControl Coordinator and Panos Christofilogiannis (AQUARK) – ParaFishControl Industry Forum Leader, with the contribution and participation of the following experts: Birgit Oidtmann (Cefas), Oswaldo Palenzuela (CSIC), Ivona Mladineo (IZOR), Marialetizia Fioravanti (Univ. BOLOGNA), Paola Beraldo (Univ. UDINE), Albert Girons (ICTIOVET), Elena Planas Callao (BIOMAR), Foteini Athanasopoulou (Univ. THESSALY), Nancy Dourala (Selonda Aquaculture SA), Carlos Zarza (ARC SKRETTING), Francesc Padrós (Univ. AUTONOMA BARCELONA), Kantham Papanna (NIREUS Group), Meritxell Díez (Grupo CULMAREX), Ioannis Petropoulos (ANDROMEDA Group), Georgios Spiliopoulos (ANDROMEDA Group), Alastair Cook (Cefas), Panos Varvarigos (VETCARE), Maria Mercè Isern i Subich (NUTRIAD International) and Daniel Gijón (SKRETTING SPAIN).

Launch of ParaFishControl Industry Forum at FEAP meeting

Venice, Italy, 18 May 2017

The Federation of European Aquaculture Producers (FEAP) Secretariat and Fish Health Commission hosted the launch of the ParaFishControl Industry Forum. During the event, Marco Gilmozzi, FEAP President, welcomed the delegates and Pier Antonio Salvador, Chairman of FEAP Fish Health Commission, presented the major industry priorities in terms of management of parasitic diseases. Dr Ariadna Sitjà-Bobadilla, ParaFishControl coordinator (IATS-CSIC) presented the Knowledge Outputs of the first two years of the project as well as the research targets for the coming years. Dr Panos Christofilogiannis, ParaFishControl Industry Forum leader (AQUARK), presented the practical outputs of the Mediterranean Mariculture experts' consultation organised in November 2016 in Barcelona, and discussed ParaFishControl's future upcoming technologies as alternatives to formalin use in aquaculture.

FEAP and ParaFishControl agreed to continue this interaction in the following years and to keep the project alignment in resolving applied industry problems in the management of parasitic diseases.

From left: Mr Courtney Hough (FEAP General Secretary), Mr Richie Flynn (Irish Farmers Association), Dr Ariadna Sitjà-Bobadilla (CSIC), Mr Marco Gilmozzi (FEAP President, API), Dr Hamish Rodger (FishVet Group), Dr Panos Christofilogiannis (AQUARK) ©AQUARK

From left: Mr Courtney Hough (FEAP General Secretary), Dr Ariadna Sitjà-Bobadilla (CSIC), and Mr Pier Antonio Salvador (President Associazione Piscicoltori Italiani, API) ©AQUARK

For more information and the full programme, please visit: bit.ly/2wbmiUw

1st ParaFishControl Industry Forum workshop held at EAFP 2017

Belfast, Northern Ireland, 5 September 2017

Both aquaculture industry and research representatives participated in the first ParaFishControl Industry Forum on Tuesday 5 September in Belfast, Northern Ireland. The event was part of the 18th International Conference on Diseases of Fish and Shellfish, and aimed to explore how the European aquaculture sector could benefit from the latest research in the area. The event facilitated effective knowledge exchange on the latest developments in fighting parasitic disease affecting aquaculture, between academia, industrial companies and fish farmer associations. This is an important goal of the ParaFishControl project.

ParaFishControl Industry Forum leader Dr Panos Christofilogiannis from AQUARK remarked "We are excited to discuss ways to improve parasitic disease management and to quantify its economic impact to the sector. This serves as the first step to mobilise all stakeholders in a sector-wide effort to combat and manage fish parasitic diseases with novel approaches and solutions.

We are confident that the ParaFishControl project knowledge outputs will contribute greatly, and the Industry Forum is the right platform to do so."

Dr Hamish Rodger, Global Managing Director of the FishVet Group, estimated the high annual economic impact for a variety of parasitic diseases in different countries, like sea lice in Norway (448-640 million Euros) and Scotland (40-56 million Euros), amoebic gill disease in Scottish farms (600-900K Euros for a 2000 tonne site) and cotton moulds (*Saprolegnia*) in Scottish aquaculture (5.5 million Euros). Mr Niels Henriksen, Danish Aquaculture Association fish pathologist, provided insights on carp and trout aquaculture, and estimated the annual impact of parasitic diseases on European trout farming to be between 30 and 60 million Euros. The impact of parasitic diseases in Mediterranean mariculture was discussed by Mr Andreas Kyriakou, fish pathologist at SELONDA Group. All attendees agreed that a coordinated effort is required involving open communication between fish pathologists, fish farmer associations and scientists, to improve impact predictions and the use of a harmonised methodology to accurately assess the significant economic impact of parasites in aquaculture.

In the second session of the ParaFishControl Industry Forum, the latest research findings and future solutions resulting from the ParaFishControl project were presented and discussed, with a focus on their relevance to the aquaculture industry and the strategy to effectively transfer these results to applied solutions for the sector. Particularly exciting news included novel disease treatments which are planned to be ready for use in the near future, progress in the ongoing search for vaccination candidate genes and feed additives, and the expectations of further expert consultations and epidemiological investigations to be undertaken in 2018.

The open discussion was launched with a short presentation by Mr Andrea Fabris, FEAP Fish Health Committee, fish pathologist API, who highlighted the industry priorities on the management and impact of parasitic diseases and the interest for an effective transfer of the project results to industry, leading to concrete suggestions for future ParaFishControl activities. This discussion proved to be a thought-provoking session to round off what was a very exciting event!

To find out more about the project's recent research findings, visit: www.parafishcontrol.eu

Industry stakeholders and interested parties are invited to join the ParaFishControl LinkedIn group to follow the projects' progress: www.linkedin.com/groups/8429051

Participating industry experts and ParaFishControl partners ©AQUARK

Parasite Portrait #2

Nematodes

In our second round of profiles focusing on parasites studied by ParaFishControl, we examine nematodes.

Anisakis simplex ©Kurt Buchmann, KU

Nematodes, or roundworms, comprise a wide range of organisms which may be free living or strictly parasitic and dependent on a host for survival and reproduction. Fish in natural waters are often infected with parasitic nematodes and some of these may even be able to infect humans. We call these parasites 'zoonotic worms'.

Anisakid nematodes

Anisakis is a genus of parasitic nematodes which have lifecycles involving fish and marine mammals. They are infective to humans and cause anisakiasis, a disease that can invade the stomach wall or intestine of humans.

Wild fish are often infected with the anisakid nematodes *Pseudoterranova decipiens*, *Contracaecum osculatum* and *Anisakis simplex*.

Third-stage larvae of *P. decipiens* occur mainly in the fish musculature (fillet), *A. simplex* are found in the body cavity, musculature and various organs and *C. osculatum* larvae predominantly reside in the liver, body cavity and pyloric caeca (finger-like projections located in the stomach of many fish species). *A. simplex* worms use whales as final hosts whereas *P. decipiens* and *C. osculatum* reach their adult stage in seals.

In seawater, free-living third-stage larvae hatch from the eggs, and various invertebrates – including euphausiids (small shrimp-like crustaceans), copepods (small crustaceans found in the sea and freshwater) and amphipods (small, flat-bodied crustaceans) – may be infected and thereby become first transport hosts. A range of fish hosts become infected following ingestion of infected invertebrates, and subsequently predatory fish accumulate significant infections by eating infected fish.

Nematode risks for aquaculture and the consumer

P. decipiens, *C. osculatum* and *A. simplex* can occur as third stage larvae in fish products, and may infect consumers ingesting raw or under-cooked fish products. If consumers get infected, anisakidosis may develop, with symptoms varying from irritation of the oesophagus and stomach to severe epigastric and abdominal pain. This infection is treated by removal of the larvae via endoscopy or surgery.

Although preventive measures comprising heat treatment or freezing will kill worms and reduce risk of human infections, it is far better to prevent infection of fish in the first place. This is what producers within European aquaculture are currently doing. Cultured salmon, rainbow trout, sea bream and seas bass are kept in captivity and fed artificial heat-treated feed their entire life. Therefore, the fish do not come into contact with the worms.

ParaFishControl research on nematodes

ParaFishControl researchers are investigating the occurrence of zoonotic nematodes in European farmed fish and they have discovered that salmon, rainbow trout, gilthead sea bream, sea bass and turbot do not carry any of these problematic roundworms. ParaFishControl researchers have examined a large number of fish farms in Europe and found them free for these vicious worms, which is good news for the European fish farm industry.

ParaFishControl

Project News

Issue 2

ParaFishControl Publications

Buchmann K, Mehrdana F. (2016). Effects of anisakid nematodes *Anisakis simplex* (s.l.), *Pseudoterranova decipiens* (s.l.) and *Contracaecum osculatum* (s.l.) on fish and consumer health. *Food and Waterborne Parasitology* 4, 13-22; doi: 10.1016/j.fawpar.2016.07.003

Granja AG, Holland JW, Pignatelli J, Secombes CJ, Tafalla C (2017). Characterization of BAFF and APRIL subfamily receptors in rainbow trout (*Oncorhynchus mykiss*). Potential role of the BAFF / APRIL axis in the pathogenesis of proliferative kidney disease. *PLoS ONE* 12(3): e0174249; doi: 10.1371/journal.pone.0174249

Mallo N, Lamas J, de Felipe A-P, Sueiro R-A, Fontenla F, Leiro J-M (2016). Role of H+-pyrophosphatase activity in the regulation of intracellular pH in a scuticociliate parasite of turbot: Physiological effects. *Experimental Parasitology* 169, 59-68; doi: 10.1016/j.exppara.2016.07.012

Mehrdana F, Buchmann K (2017). Excretory/secretory products of anisakid nematodes: biological and pathological roles. *Acta Veterinaria Scandinavica,* 59(1), 42; doi: org/10.1186/s13028-017-0310-3

Piazzon MC, Galindo-Villegas J, Pereiro P, Estensoro I, Calduch-Giner JA, Gómez-Casado E, Novoa B, Mulero V, Sitjà-Bobadilla A and Pérez-Sánchez J (2016). Differential Modulation of igT and igM upon Parasitic, Bacterial, Viral, and Dietary challenges in a Perciform Fish. *Front. Immunol.* 7:637; doi: 10.3389/fimmu.2016.00637

Rigos G, Mladineo I, Nikoloudaki C, Vrbatovic A, Kogiannou D (2016). Application of compound mixture of caprylic acid, iron and mannan oligosaccharide against *Sparicotyle chrysophrii* (Monogenea: Polyopisthocotylea) in gilthead sea bream, *Sparus aurata*. *Folia Parasitologica* 63, 027; doi: 10.14411/fp.2016.027

Sándor D, Molnár K, Gibson DI, Székely C, Majoros G, Cech G (2017). An investigation of the host-specificity of metacercariae of species of (Digenea: Heterophyidae) in freshwater fishes using morphological, experimental and molecular methods. Parasitology Research; doi: 10.1007/s00436-017-5617-5

Sitjà-Bobadilla A, Oidtmann B (2017) Integrated Pathogen Management Strategies in Fish Farming, Chapter 5, In: Jeney , G. (Ed.). (2017). Fish Diseases: Prevention and Control Strategies. Academic Press. eBook ISBN: 9780128045855, Paperback ISBN: 9780128045640

Wiegertjes GF, Wentzel AS, Spaink HP, Elks PM, Finka IR (2016). Polarization of immune responses in fish: The 'macrophages first' point of view. *Molecular Immunology* 69, 146-56; doi: 10.1016/j.molimm.2015.09.026

CONTACT US

@parafishcontrol

parafishcontrol.eu

ParaFishControl

CSIC
INRA Transfert

Coordination and Management:
parafishcontrol.coordination@csic.es
Supported by INRATransfert:
enric.belles-boix@inra.fr

AQUATT
Science. Communication. Knowledge. Innovation.

Communication and Press:
marieke@aquatt.ie
claudia@aquatt.ie

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement no. 634429 (ParaFishControl). This output reflects only the author's view and the European Union cannot be held responsible for any use that may be made of the information contained therein.