ParaFishControl

KEY EXPLOITABLE RESULTS AND IMPACT

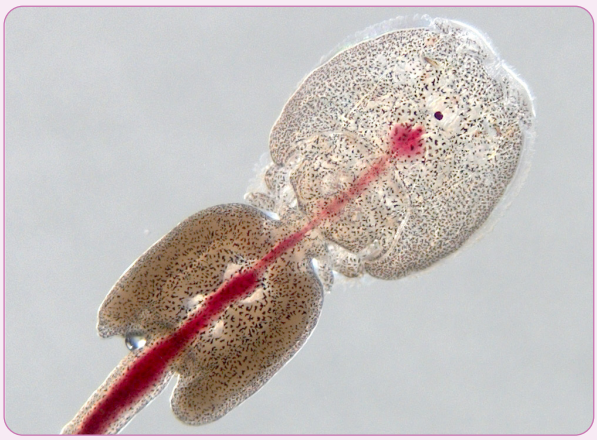
28 PARTNERS

13 COUNTRIES

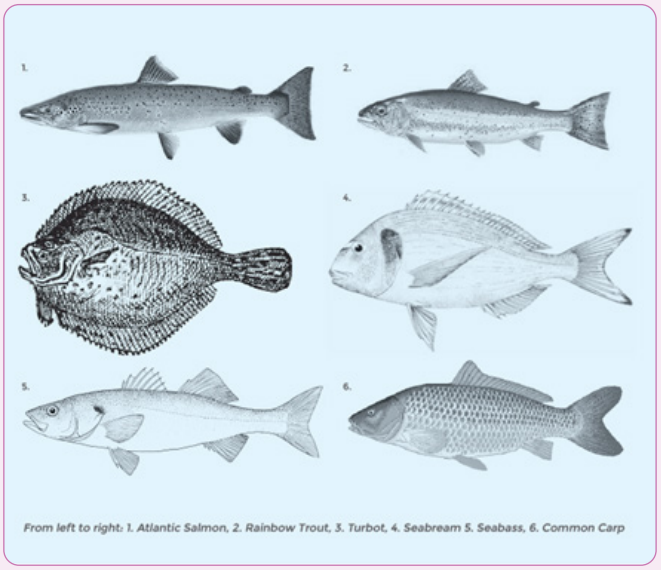
Introduction

Aquaculture is the fastest growing food producing sector worldwide, currently providing half of all aquatic animals for human consumption. If responsibly developed and practised, aquaculture can generate lasting benefits for global food security and economic growth.

Disease prevention and management are essential for the sustainability of the European aquaculture industry. The diversity of species and farming practices throughout Europe involves a significant number of threats related to a large variety of pathogens that hamper production. Specific preventive and curative practices and tools are required to ensure a high level of biosecurity for aquaculture production and related seafood products. Among other disease-related threats, parasites and related infections can cause significant damage to farmed fish species, which can result in poor growth performance, impaired welfare, and high mortality rates with significant consequences for production and economic performance.



Lepeophtheirus salmonis © L. A. Hamre, SLRC



ParaFishControl target fish species

The aim of the EU-funded, H2020 project, **ParaFishControl** was to improve the understanding of fish-parasite interactions and to develop innovative solutions and tools to diagnose, prevent and treat the most harmful parasites which affect the main fish species farmed in Europe, including Atlantic salmon, rainbow trout, common carp, turbot, European sea bass, and gilthead sea bream.

The parasites studied in the **ParaFishControl** project included: *Amyloodinium ocellatum, Ceratothoa oestroides, Enteromyxum leei, Enteromyxum scophthalmi, Enterospora nucleophila, Ichthyophthirius multifiliis, Lepeophtheirus salmonis, Neoparamoeba perurans, Philasterides dicentrarchi, Saprolegnia parasitica, Sparicotyle chrysophrii, Sphaerospora molnari, Tetracapsuloides bryosalmonae* and *Thelohanellus kitauei* as well as zoonotic helminths.

Key Exploitable Results

This interactive factsheet summarises the **Key Exploitable Results (KER)** arising from five years of research carried out by the **ParaFishControl** partners. The KERs have been categorised as follows:

A Diagnostic tools and strategies

B Prevention tools and strategies

C Treatments

D Specific tools for farm managers

E Policy recommendations

F Results for research

Diagnostic tools and strategies

Early diagnosis of parasitic diseases in aquaculture farms is crucial so that immediate action can be taken to avoid a disease outbreak in the farm.

ParaFishControl partners have developed new diagnostic tools for emerging parasites such as *E. nucleophila*. In addition, they have also advanced the development of reference diagnostic methods for other parasites such as *T. bryosalmonae, S. molnari* and *T. kitauei*. As part of this work in diagnostics, **ParaFishControl** research has also advanced towards the creation of easy to use and rapid kits for the detection of *E. leei, E. scophthalmi* and *Anisakis*.

1	Two novel diagnostic reference techniques for the parasite *Enterospora nucleophila* validated	7	New antigen and optimised protocols to detect the fish proliferative kidney disease - causing parasite, *T. bryosalmonae*
2	Novel highly specific and sensitive qPCR for *Sphaerospora molnari* validated	8	Comparison of DNA extraction methods and development of an on-site portable system to detect the amoeba, *N. perurans*
3	Validated novel highly specific and sensitive diagnostic tool, qPCR, for the common carp parasite, *Thelohanellus kitauei*	9	Identification of six *Enteromyxum* spp. molecules as candidate targets in lateral flow test (LFT) diagnostic tests
4	Portable and easy-to-use detection method for *Anisakis*, a parasite which causes significant health risk in raw fish	10	Diagnostic tool to quantifiably detect the parasite *Philasterides dicentrarchi* in fish and seawater (qPCR)
5	Portable toolkit to monitor zoonotic helminths in farmed and wild fish	11	Repository of diagnostic methods for the most harmful parasites in European aquaculture farms
6	Multiplex PCR for simultaneous identification of the most common European Opisthorchiid and Heterophyid in fish		

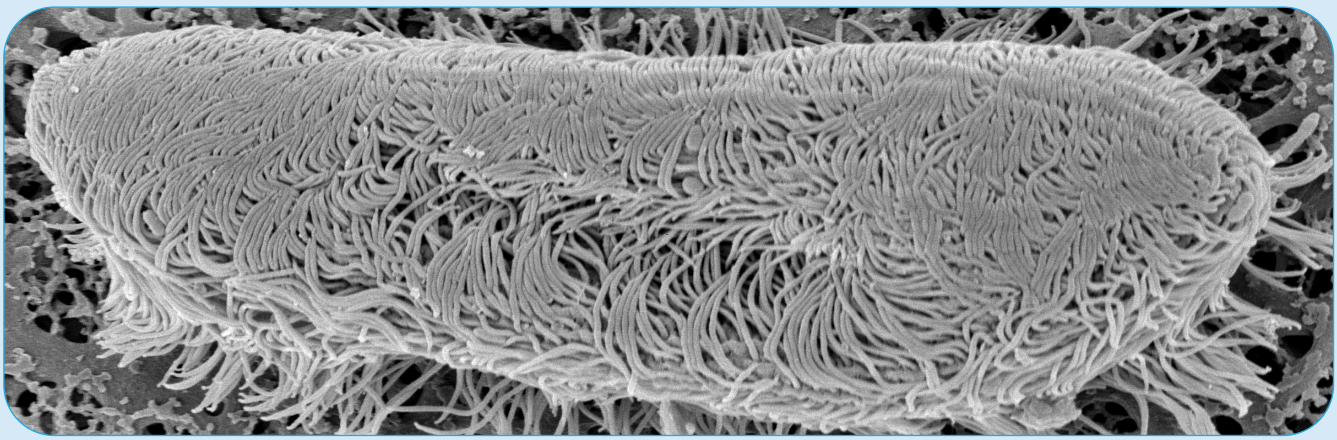
Prevention tools and strategies

Vaccination has proven to be a key enabler of the recent global growth of aquaculture, and to be an efficacious, environmentally friendly method for combating disease. As an approach, it also helps to generate favourable consumer perception of the aquaculture industry, in contrast to the use of chemotherapeutants. Licensed vaccines exist for 22 bacterial and 6 viral diseases of fish. Although considerable research is currently being conducted both in Europe and globally into sea lice vaccines, most finfish parasites have been largely neglected. In **ParaFishControl**, advances have been made towards obtaining vaccines against a selected number of parasites.

New candidate vaccines have been successfully tested for all the target parasite species. In particular, vaccines against *I. multifiliis, P. dicentrarchi, S. parasitica* and *A. ocellatum* infections all show some level of significant protection, either in terms of reduction in the number of infecting parasites or in the amelioration of pathology and other clinical signs of disease.

The new vaccines are at different stages of development; some have been tried *in vitro*, others *in vivo*, and some have been tested in the field. **ParaFishControl** research has also investigated immunostimulants that could be used as feed additives.

12	Candidate protective antigens which could be used for a universal vaccine against *Philasterides dicentrarchi* identified	17	Progress towards the development of a vaccine against *Saprolegnia parasitica* in Atlantic salmon
13	Progress towards a vaccine for *Amyloodinium ocellatum*	18	EpitopePredikt: Artificial Intelligence software to improve the diagnostic and vaccine generation processes
14	Identification of an antigen suitable to progress towards creating a vaccine against *Ichthyophthirius multifiliis* (ICH)	19	Functional feed additives reduce the impact of *Enteromyxum leei* in gilthead sea bream
15	Progress towards developing a vaccine for *Sphaerospora molnari*	20	Efficiency of feed additives as an alternative treatment for the parasite *Ichthyophthirius multifiliis* in rainbow trout
16	Efficacy of vaccine candidates as prophylactic treatments for proliferative kidney disease (PKD) in rainbow trout	21	Effects of immunostimulants in feed against the parasite *Sphaerospora molnari* in common carp



Ichthyophthirius multifiliis © O. S. Møller, University of Copenhagen

Treatments

For the European aquaculture industry to manage parasite infections effectively, environmentally-friendly, safe and cost-effective compounds are needed to be used for use within an integrated pest management system (IPMS). **ParaFishControl** has worked towards the development of new, natural treatments against a number of parasites.

22	Eco-friendly and natural treatment against *Ichthyophthirius multifiliis*	24	Identification of compounds with potential to treat sparicotylosis in sea bream
23	Comparative effectiveness of potential treatment candidates for salmonids affected by *Saprolegnia*	25	Identification of potential compounds to treat the parasite *Ceratothoa oestroides* in sea bass

Specific Tools for Farm Managers

ParaFishControl has developed specific tools to help farm managers to control parasitic diseases in their farms. These tools provide information to support the management of the main disease-causing parasites affecting the farming of salmonids, turbot, carp, seabass and seabream in European countries. The resources include background on the parasites' biology, an examination of key risks for infection and disease progression, up-to-date guidance for the identification of symptoms, as well as guidance on management and control of the parasite. As well as in-depth manuals, resources include presentations and other written guides.

26	Fish Farmer's Guide to Combating Parasitic Infections in Salmonid Aquaculture	32	Integrated Pest Management Strategies for *Saprolegnia*
27	Fish Farmer's Guide to Combating Parasitic Infections in European Sea Bass and Gilthead Sea Bream Aquaculture	33	Integrated Pest Management Strategies for *Philasterides dicentrarchi*
28	Fish Farmer's Guide to Combating Parasitic Infections in Common Carp Aquaculture	34	Integrated Pest Management Strategies for *Enteromyxum leei*
29	Fish Farmer's Guide to Combating Parasitic Infections in Turbot Aquaculture	35	Integrated Pest Management Strategies for *Sparicotyle chrysophrii*
30	Integrated Pest Management Strategies for Sea Lice	36	Free online tool for farmers to plan parasite control in Mediterranean aquaculture
31	Integrated Pest Management Strategies for *Neoparamoeba perurans*	37	Voluntary Control System to monitor the presence/absence of *Anisakis* (and other zoonotic helminths) in farmed fish

Policy Recommendations

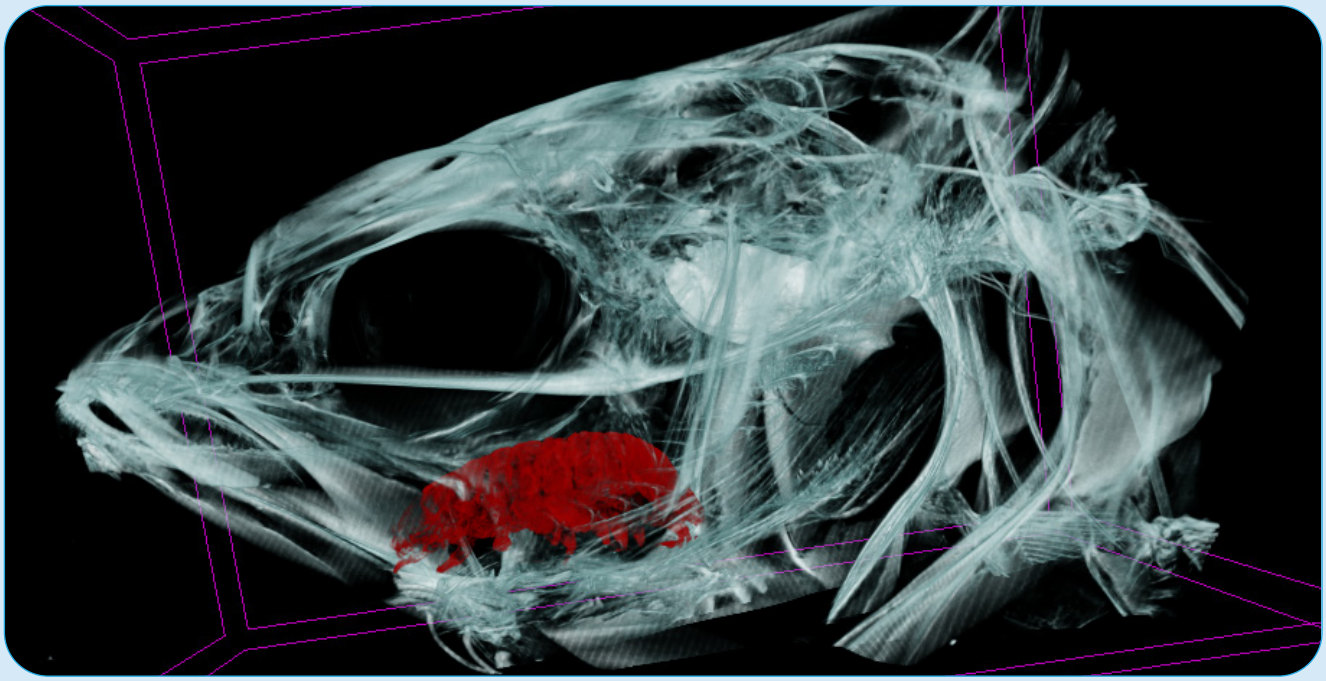
Ensuring the quality and safety of farmed fish products is of paramount importance to reinforce the competitiveness of European aquaculture. **ParaFishControl** contributed to this aim by working towards identifying cultured fish products potentially contaminated by helminths that could represent a human health hazard. As a result of this work, policy changes in relation to restrictions placed on European aquaculture have been proposed by **ParaFishControl**.

38	European-wide study reveals negligible risk for human health of zoonotic parasitic worms in farmed fish

Results for Research

ParaFishControl has significantly advanced scientific knowledge on fish parasites. This includes developing and optimising *in vivo* and *in vitro* models, deciphering the mechanisms by which parasites, hosts and intermediates interact in order to allow development of targeted therapy strategies, and describing parasite life-cycles that were previously poorly understood.

39	Repository of *in vivo* and *in vitro* infection model Standard Operating Protocols for selected parasites
40	Genome and transcriptome sequencing for selected parasites



Ceratothoa oestroides © P. Katharios and K. Keklikoglou, HCMR

ParaFishControl

Key Expoitable Results and Impact

Impact

The aim of the **ParaFishControl** project was to **increase the sustainability and competitiveness of the European aquaculture industry** by improving the **understanding of fish-parasite interactions** and by developing **innovative solutions and tools for the prevention, control and mitigation** of the most harmful parasitic species affecting the main European farmed fish species.

During the past five years (2015-2020), **ParaFishControl** partners have worked together to generate new aquaculture-relevant scientific knowledge concerning key fish parasites, identifying key elements of the host immune response, including patterns of gene/protein expression, and downstream effects on parasites as well as investigating the epidemiology of parasites that show reciprocal movements between farmed and wild fish host populations. **ParaFishControl** focused on the **diagnosis and detection** of parasites in aquaculture farms both in the fish and the environment, the **prevention** of parasitic infections through progression of vaccine development, as well as on **novel treatments** in compliance with European legislation to avoid parasite resistance, toxicity of chemicals, and persistence of chemical residues in fish and the environment. It has also contributed to the development of Integrated Pest Management Strategies and a series of guides to combating parasitic diseases in European aquaculture farms. The project has also promoted the **creation and growth of new biotechnology SMEs** that can now provide new innovative services to the European aquaculture sector.

The impact of this newly generated knowledge and development of targeted intervention strategies, new and more efficient diagnostic tools and immune-modulatory strategies and drug designs, is significant for the European aquaculture sector. These results will enable disease prevention and management which are essential for the sustainability of the European aquaculture industry. These tools directly respond to the challenges and threats affecting aquaculture farmers in Europe caused by parasites, such as hampering production. The **ParaFishControl** project results can contribute towards an improved level of biosecurity of aquaculture production and related seafood products. To ensure that all the results are used by the key European stakeholders in the aquaculture sector, **ParaFishControl** has carried out customised activities for each target audience, including directly to industry. The result of this effort has translated into new collaboration agreements and further funding to continue developing some of the results presented within this document.

Overall, the ParaFishControl consortium believe their anti-parasite outcomes could lead to an increase in sustainability and competitiveness of the European aquaculture industry.

Designed and developed by AquaTT

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