Ref. Ares (2018)4843939 - 20/09/2018

Intelligent Fish feeding through Integration of ENabling technologies and Circular principle

Grant Agreement (GA) No: 818036

D6.10: Training Tutorials and academic curricula

Version: 3.2

Date: 31. 05. 2023

Document type:	**Report**
Dissemination level:	**Public**

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 818036

Project data

Project Title:	Intelligent Fish feeding through Integration of ENabling technologies and Circular principle
Project Grant Agreement (GA) No:	818036
Project Acronym:	iFishIENCi
Duration:	57 months, 1 November 2018 – 31 July 2023
Type of action:	Innovation Action

Deliverable Administration and Summary

Status:	Draft	**Due:**	31/03/2023	**Date:**	31/3/2023
Author (s)	Julianna Kobolák (MATE), Dorothy Dankel, T Nilsen (UiB), Dannie O'Brien (ABT)				
Reviewer	Dannie D. O'Brien, ABT (WP6 Leader)				
WP	6	**Deliverable Nr.**	**D48**	**Relative Nr.**	D.6.10
Comments					

Document change history

Version	Date	Author	Description
1.0	21/10/2021	J. Kobolák, B. Kovács	
2.0	01/11/2021	D. J. Dankel	revised
3.0	01/12/2022	J. Kobolák	revised
3.1	13/03/2023	D.J. Dankel & T.O.Nilsen	Norwegian M.Sc programs added, plus in Appendix 1, additions from Scotland, Norway and ERASMUS Joint Master program
3.2	20/5/2023	D. O'Brien	Revised Greek and Maltese program, Norway program, Review.

Disclaimer:

This document reflects the view of the author(s). The Research Executive Agency (REA) and the European Commission are not responsible for any use that may be made of the information it contains.

Suggested reference to this deliverable: iFishIENCi D6.10: Training Tutorials and academic curricula (2023), Intelligent Fish feeding through Integration of ENabling technologies and Circular principle (iFishIENCi) Horizon 2020 project under Grant Agreement (GA) No: 818036

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 818036

Table of Contents

1 Summary

There is a need for new developments and technological advancements to be incorporated into training materials for the next generation of aquaculture professionals, especially in the academic curricula of higher educational institutions. This requires the understanding and appropriate knowledge of existing training systems and needs from the side of the aquaculture industry. Task 6.6 of WP6 aims to understand the needs of the European aquaculture industry and develop training materials that could provide relevant knowledge regarding new technological developments in aquaculture to existing and new professionals.

2 Introduction

The overall goal of the iFishIENCi innovation action project is to provide new intelligent feeding technologies to support ambitious, but sustainable, growth for the European aquaculture industry by developing and integrating cutting-edge technologies. For these technological developments to become a part of aquaculture practice and thus able to increase the sustainability of the industry, it is necessary to disseminate the new developments through quality training of professionals. As such, successful developments should become a part of the academic curricula and be integrated into the teaching materials of higher educational institutions, training the next generation of fish farmers. The rapid technological development and intensification of the modern aquaculture industry necessitate enhanced integration of research, innovations, and knowledge. Task 6.6 aims to further develop and increase the competitive edge of the European aquaculture landscape by reconciling and strengthening the competencies of present and future fish farmers and educators.

Coupling of research innovations and educational programs in iFishIENCi:

- will ensure the education of candidates with suitable competence for the industry;
- will train present fish farmers to increase uptake of new technologies;
- will integrate feedback from the industry through training sessions hosted by iFishIENCi partners (WP3) and industries (end users);
- will contribute to the development of new and/or adapted BSc., MSc., and MBA programs that are compatible with the rapidly changing needs for knowledge in modern future fish farming;
- will also include applied Aquaculture RRI workshops;
- and the newly funded Norwegian project KABIS (capacity boost for sustainable and innovative seafood production), coordinated by NORCE/ UiB will provide the basic material and information for the internationalization of training and capacity building to be conducted through iFishIENCi.

3 Training concept development

3.1 The training concepts

For sustainable European aquaculture to succeed, we in the iFishIENCi science-industry consortium have unique insight into the different educational needs of diverse groups of people (university students, teachers, fish farmers, professionals, and experts in the aquaculture industry). Considering these different needs, we identified three main areas – three pillars – where different training could be organised and different educational materials could be developed:

1. Integration of new technologies and concepts into existing BSc/MSc courses and MBA programs (into existing/accredited academic curricula) and training of thesis students in iFishIENCi concepts/technologies.
2. Development of a new English language MSc course in Aquaculture and Fisheries, suitable for accreditation in a higher education institution in Hungary and finalisation of the Aquaculture Integrated Master in Norway.
3. Training courses for professionals through mobility and farm visit programs.

4 Integration of new technologies and concepts into existing courses and programs

4.1 The need

We see the importance of the development of thematic lectures (e.g., Blue economy and fish farming in the 21st century; Digitalisation and AI in Aquaculture) which can be incorporated into existing courses of different educational systems (existing/accredited academic curricula). Elements (individual lectures) or the whole course can be integrated within the consortium and partner project members, depending on the existing theme of the accredited BSc/MSc course of different Universities (in various countries).

4.2 The landscape

In the EU, there is a decades-long tradition of economic and social embedding of education levels. After the basic level of education, special training courses oriented towards aquaculture (fishing and fish processing) appear in the secondary level education, the output of which is that the young graduates immediately enter the sectoral labor market at the level of a skilled worker or technician. Higher education institutions are based on this, and they train professionals with university degrees who have acquired higher-level knowledge and skills. Professionals graduating at both levels and working in the profession can be kept up-to-date through continuous training and learning of new knowledge, developments, and technologies.

Comparing aquaculture education with agricultural training, two significant differences in the acquisition of knowledge can be identified: i) agricultural training has a long and serious tradition in Europe, in contrast to aquaculture training, which has only taken the initial steps in its development; ii) the output needs of agricultural training, the educational platforms adapted to them operate along well-defined, exact labour market suburbs, in contrast to aquaculture-type training, where the identification of market needs is still ongoing, in some cases we only encounter definite needs. As a result, aquaculture education in Europe shows a diverse picture: there are real, typically Master's programs (MSc) that provide only aquaculture knowledge, and there are courses where aquaculture is part of a specific course, e.g., within animal husbandry.

4.3 The current structure of higher education trainings

As a first step SZIU/MATE, the Hungarian Agricultural University partner in iFishIENCi, investigated the existing university courses and training materials in Hungary and collected the aquaculture-related curricula currently in use. As a result, 30-course descriptions were collected related to aquaculture and fisheries studies in Hungary, containing the basic course data, compulsory and additional literature, and the professional content of the course in Hungarian. These courses (provided in the Hungarian language) are for BSc or MSc students, mainly part of animal husbandry or ecological studies, provided by three higher educational institutions in Hungary (MATE, DE, and SZE). Upon analyzing the results, it was clear a comprehensive aquaculture MSc-level training does not exist in Hungary, only postgraduate specialist training courses are available in the field (e.g., Fisheries engineering; Fisheries and fish farming management).

A similar exercise was carried out at the University of Bergen (partner in iFishIENCi) in Norway. As the world-leader in Atlantic salmon aquaculture exports, with one of the world's longest coastlines and already high technological competence and world-leading technology, Norway has a major competitive advantage in aquaculture on a global basis. Bergen is considered “The Silicon Valley” of aquaculture, and two important M.Sc programmes exist at the University of Bergen.

The Norwegian M.Sc programme in Aqua Medicine is based in the natural sciences. Through research-based instruction, the students learn the biology of aquatic organisms, pathogens, and the impact of environmental factors, i.e. conditions that can lead to the development of illness and injury. The students learn modern and appropriate methods of diagnosis and are given thorough insight into the prevention and treatment of illness and injuries in aquatic organisms. Education in aqua medicine encompasses a wide range of topics that encompass work in the aquaculture industry, aquatic animal health services, management, and educational and research institutions.

The programme provides the student with insight into the biology of aquatic organisms and interactions among these organisms, pathogens and external environmental factors. The education also covers the primary aquatic animal health service and gives insights into the organization and legislation related to fish farming and disease. The programme helps to focus students’ ethical reflections on and awareness of animal husbandry and animal experiments, promotes respect and understanding of biological factors and provides insight into environmental and health perspectives on a global scale. Through specialization, the students develop a reflective and critical scientific mind-set and a deliberate approach, interpretation, and presentation of their own research results. The programme meets the requirements set for certification as an aqua medicine biologist, and strict requirements are set for the content of the study so that most elements in the programme are compulsory. Upon completion of the programme, the students can apply for the title of aqua medicine biologist (Fiskehelsebiolog), by applying to the Norwegian Food Safety Authority (FSA). The title of aqua medicine biologists is regarded as equivalent to the title of veterinarian in Norwegian legislation, and candidates who have been awarded the title have the same rights as the veterinarians regarding treating diseases in aquaculture. The title gives limited prescription rights.

In addition, Norway has a 2-year master’s program in Aquaculture Biology. Aquaculture Biology is a specialization in the Master's Programme in Biology. The goal of the Aquaculture Biology specialisation is to give a theoretical basis and practical experience for understanding the biological principles in aquatic food production. Aquaculture is a diverse discipline, covering topics such as molecular biology, chemistry, nutrition, as well and the biology, physiology, and behaviour of fish. The practical work of aquaculture takes place in the laboratory, the hatchery, or the fish farm. The courses in this specialization provide an insight into the role of aquaculture in global food production, and the

knowledge and skills needed for its further development. The student research project can be undertaken in a commercial setting or at a research institution. The research question may be focused on a fundamental biological process or be designed to test and refine production techniques or instrumentation. The specialization is intended to give a solid background for students who wish to work in aquaculture or related industries, or to pursue further research.

The University of Bergen has a bachelor's level course on Recirculating Aquaculture Systems (RAS). The Department of Life Sciences offers a collection-based course of 5 credits, which will provide basic insight into and applied knowledge of biological, environmental and technological processes that are central to the farming of fish using recycling. The course provides a basic understanding of the interaction between fish physiology, water quality, operation of the biofilter, as well as the technical structure and function of various components in a RAS system. The course covers the following topics:

- Life cycle of salmon
- Water quality in RAS, treatment of intake water
- RAS facility, structure and function
- Filtration of production water
- Biofilter, TAN turnover
- CO2 venting, gas equilibria and buffering
- Disinfection of production water, microbial control
- Oxygenation
- The breeding unit, facility design
- Production of salmon in RAS, operational challenges
- Water quality challenges (CO2, TAN, colour, particles, H2S etc.)
- Growth, optimal lining
- Temperature control
- Light treatment smoltification
- Maturation of male fish
- Hygiene control
- Health challenges/illness
- Movement of fish/export
- Trends in modern RAS production (brackish water, postsmolt, intensity, dimension, production strategy etc.)
- Design and dimensioning
- Regulations

After completing the course, students have basic knowledge of fish physiology and environmental requirements to ensure optimal development, growth and good health. After completing the course, students can carry out relevant sampling (water samples and biological samples) as well as be able to analyse and interpret the results and be able to adapt the operation of a RAS facility according to environmental information and an understanding of the fish's physiology. Students learn to make calculations related to biomass, biofilter capacity and environmental conditions that ensure the best possible conditions, aligned with the regulations surrounding RAS. The course is a part-time study with a weekly session at the Department of Biological Sciences and the RAS facility at Marineholmen, centrally located on the UiB campus near the centre of Bergen. In addition, online teaching is provided throughout the semester via UiB's learning platform "MittUiB" and the course participants write a written project assignment. The weekly session consists of lectures, group work, discussions and laboratory work at RAS facilities. The course is aimed at employees in the farming industry who want

greater knowledge and competence in the operation of RAS facilities. Students must have a vocational certificate in aquaculture/mariculture, or be over 25 years old and have a minimum of 5 years' professional experience from the aquaculture industry. There are 20 study places for the course.

As a next step, we mapped the European landscape and gathered information about the existing academic curriculum. As it can be concluded, 22 countries among the EU member states (MS) and 10 non-EU countries have BSc or MSc level higher education courses in Aquaculture or closely related topics, partially covering fisheries and aquaculture (**Appendix 1.**). The educational institutions which are providing BSc/MSc studies in the field, usually provide further post-graduate (e.g., PhD course) or special courses for specialization. In some institutions, these courses are available only in the national language, but several institutions provide their studies in the English language as well for their students (see Table 1). Although detailed curricula are not available everywhere on the website of the Institutions, on average the length of the courses is 2 years (4 semesters) but it varies between 3 semesters up to 5 years. The structure of the courses is very diverse, but some common features can be concluded:

- most courses start with common basics (e.g. fish biology and ecology; aquaculture systems; basic economy, fish breeding, fish nutrition; health management);
- in the second half of the training specializations (e.g. marine aquaculture; fish genetics, farm management);
- optional courses can be chosen (e.g., economics, environmental management, angling) during the studies;
- internships are not appearing in every curriculum, but thesis writing is accounted for among the credits.

The courses are providing hands-on training opportunities, moreover, the majority of them require the students to spend at least part of their studentship in the industry environment. This is true for more of the MSc and PhD training where the thesis works is often related to field studies and less for the BSc level, but county specific differences can be relevant.

The shortage of well-trained professionals in the European aquaculture sector is linked to several causes. One is the low number of higher education students in the field which can be related to the current structure of higher education level courses (e.g., few aquaculture-specific courses are available; the existing courses are rather ‘conventional’, rather than using new digital methods), but also to the not well-marketed status of such MSc and BSc courses. The young generations, and the current teenagers’ “consumption habits” have changed in the internet age and with the rise of social media. This is true for their habits related to acquiring knowledge as well. Therefore, two main aspects which could increase the number of students entering the MSc courses in higher education institutions would be:

- changing the structure of their courses including new educational methods (e.g., more digital options; e-learning modules; interactive, video-based mentoring; trainings at industry partners)
- increasing the marketing of their aquaculture courses (e.g., campaigns, open days, direct ‘recruiting’ and info days in secondary schools, mentoring of secondary school students, scholarships, summer camps)

There are good examples already (e.g., Netherlands: Wageningen University; Spain: collaboration between national universities) which should be adapted to the local needs and specifications of the sector both in using digital tools and methods and marketing their courses.

Appendix 1 presents the higher educational aquaculture training (both BSc or MSc level) landscape of Europe. All EU Member States (MS) and European Associated Countries (e.g. Norway, Switzerland, Great Britain) and non-EU-Member countries and trans-continental ones (e.g. Russia, Georgia, Turkey) with aquaculture activities are listed in the Table. The countries are presented in alphabetical order, presenting the **currently running accredited courses** of each country. We have indicated by colour code when the major BSc or MSc curricula is not in aquaculture-related, but research and thesis topics can be chosen in aquaculture (e.g., in Hungary).

4.4 Integrating the knowledge

4.4.1 Supplementing existing academic curricula

To make rapidly integrate new knowledge and information about aquaculture research and developments into practice in the quickest way, iFishIENCi proposes that we should generate topic-specific lecture materials which can be used and presented as part of existing (accredited) training programs. Due to the specific rules of how academic curricula should be accredited and modifications implemented (local and national academic committees must discuss and accept in a long process), part of the lectures can be extended, and short materials can be incorporated into current academic materials. At many organisations it is a long academic process to modify the curricula and integrate new lectures, which makes it complicated and extends the integration of new, complex materials. The integration of new pieces of information, and short materials about the developments and innovations are more realistic and could be the decision of the lead lecturer who is responsible for a given course. iFishIENCi partners, participating in technology development provide technology descriptions and short training materials which can be used for educational purposes as listed in **Table 1**. These materials are deposited according to the DMP of the iFishIENCi of the project and are available for use. For example, MATE will build these materials into existing courses listed in **Appendix 2**.

Table 1: List of training materials developed in iFishIENCi for integration to existing courses/lectures.

Topic	Provider	Technology or new area covered
Genetic breeding in aquaculture	MATE	New approaches applied in genetic marker-based selection technologies in aquaculture
RRI	UiB	Application of reflexive approaches in aquaculture science, focusing on anticipation and responsiveness to the business, political and societal needs in aquaculture
Circularity in aquaculture	LEITAT/ABT	Circularity in aquaculture – how to reach it: problems, bottlenecks, new developments and possibilities
Sensor technology and digitalization in aquaculture	BIOCEANOR/HCMR/ EGM	New developments and applications in automatization and sensor technology in aquaculture

4.4.2 Stand-alone webinars, online events and lectures

Another way to quickly disseminate innovations is to organize specific lectures and webinars about specific topics and provide information through these events, which can be directed to both current students as well as established academics, industry, and also interested investors or multidisciplinary actors/changemakers. iFishIENCi partners, participating in technology development will provide

technology descriptions and short training materials which can be used for educational purposes. As listed above in 4.3.1 similar materials can be used as a basis for specific lectures/webinars, supplemented on an occasional basis to fit the overall concept of the webinar/lecture.
During the lifetime of the project webinars were organised in different topics providing materials which can be used in professional trainings and available on an organised manner at the repository of the project, listed in Table 2.

Table 2. List of online events with training elements

Event	Repository	Topic
Aquaculture Going Circular Online 9th November 2021	https://ifishienci.eu/media/events/aquaculture-going-circular/ **video:** https://youtu.be/3Tt1mIA3jcc Policy Recommendations for a More Circular Aquaculture (IfishcIENCi_Policydoc_Jan-2022Final..pdf (ifishienci.eu)) DOI: https://doi.org/10.5281/zenodo.6641751	circularity in aquaculture
From Blue To Green Online Workshop 25th October 2022	https://ifishienci.eu/media/events/from-blue-to-green-aquaculture-innovation-and-synergies-with-agriculture/	Circularity and digitalisation in aquaculture with synergies for agriculture.
Horizon For Aquaculture Online June 2021	https://ifishienci.eu/horizon4aquaculture/	Sustainability in aquaculture: Policy and Regulation, Circularity, Precision Aquaculture
From data interoperability to data spaces in the aquaculture domain	https://ifishienci.eu/from-data-interoperability-to-data-spaces-in-the-aquaculture-domain/	Data interoperability in aquaculture, precision aquaculture
GAIN H2020 aquaculture summer school lecture	https://youtu.be/QdHp-O2f-Fk	Precision aquaculture, Circularity, feeding efficiency
PRACTI-RAS Online Recirculating Aquaculture Train the Trainer Erasmus+ course lecture	https://pas01.moodlecloud.com/	Novel feeds, SmartRAS
Web conference European Association of Fish Pathologists, Hannover	Closed training. Audience of scientists, pathologists, trout farmers, No.(participants) 50	Functional feeds against bacteria diseases

4.4.3 Student involvement in the iFishIENCi Project

To ensure immersive training of future professionals in the iFishIENCi concepts and innovations, sixteen BSc/MSc and PhD students were trained in the iFishIENCi project, performing their scientific work as part of the project activities or related to the new developments. Altogether 13 BSc/MSc Thesis and 3 PhD thesis was prepared or still in progress as listed in **Table 3.**

Table 3. BSc/MSc and PhD thesis prepared in frame of the project.

Type	Relevant WP	Thesis Title	Supervisor (Partner)	Comments
BSc/MSc	WP1	Natalie Panasiak: Beyond the Crystal Balls: iFishIENCi of Feeding Behaviour and Stomach Fullness Methods in RAS Cultivated Rainbow Trout (Oncorhyncus mykiss)	Dr Steven G Prescott (co-supervisor) (ABT)	Erasmus Mundus Joint Masters Degree- Completed
BSc/MSc	WP6	Maria Compte Ejarque: Connecting iBOSS circularity to the UN SDG Targets and sustainability Reporting using "SDG Wizard"	Dorothy Dankel (UiB)	ERASMUS+ mobility programme
BSc/MSc	WP1, WP4	Matthew Fenech Gonzi: Assessment of a Recirculating Aquaculture System with focus on Energy and Water/Effluent Sustainability- SmartRAS	Dr Simeon Deguara (ABT)	BSc. with University of Malta, in progress
BSc/MSc	WP1, WP3	Enikő Sásvári: Genetic diversity analyses of intensively bred African catfish (Clarias gariepinus)	Dr Balázs Kovacs (co-supervisor) (SZIE/MATE)	Completed 2020
BSc/MSc	WP1, WP3	Veronika Varga: Gene expression analyses of sex-related genes in African catfish (Clarias gariepinus)	Réka Enikő Balogh / Dr. Kovacs Balazs (SZIE/MATE)	Completed 2020
BSc/MSc	WP1, WP3	Karl Reginald Managa: Microsatellite Marker Adaptation for Population Genetic Analysis of Vundu (Heterobranchus longifilis) and African catfish (Clarias gariepinus) hybrids	Dr Balázs Kovacs (co-supervisor) (MATE)	In progress
BSc/MSc	WP1, WP3	Peter M. Vadasz: Feed intake and gut evacuation of rainbow trout	Dr Giovanni Gusmanno (co-supervisor)(ABT)	BSc. Thesis project - Starting
BSc/MSc	WP1, WP3	Andrew Mallia: A video analysis of fish behaviour in a Recirculating Aquaculture System (RAS)	Dr Simeon Deguara (ABT)	Completed 2022
BSc/MSc	WP1	Hilde Moberg Vossgård: Valorisation of aquaculture waste using microalgae	Dorinde Kleinegris (NORCE) / Pia Steinrücken (UiB)	Completed 2022
BSc/MSc	WP1, WP3	Alexandre Miguel Poeira Jose: Detecting behaviour patterns using video analysis of rainbow trout (Oncorhyncus mykiss) in recirculating aquaculture systems (RAS)	Dr Steven G Prescott (co-supervisor) (ABT)	In progress
PhD	WP1, WP3	Réka Enikő Balogh: Molecular genetic analyses of the development of African catfish	Dr Balázs Kovacs (MATE)	In progress
PhD	WP1, WP3	Dániel Péter: Molecular genetic characterization of African catfish growth	Dr Balázs Kovacs (MATE)	In progress

PhD	WP1, WP3	I-Hao Chen: Machine vision & behavior in fish	Lars Ebbesson & Nabil Belbachir (NORCE) Antonella Zanna Munthe-Kaas (UiB)	In progress 2021-2024
BSc/MSc	WP1, WP3	Marie Bø Randulff "Towards more sustainable feed solutions in aquaculture"	Dr. Naouel Gharbi, Dr. Neda Gillanejad & Patrik Tang NORCE	In progress 2022-2024
BSc/MSc	WP1, WP3	Kristine Ovidia Rostad "Towards more sustainable feed solutions in aquaculture"	Dr. Naouel Gharbi, Dr. Neda Gillanejad & Patrik Tang NORCE	In progress 2022-2024
BSc/MSc	WP1, WP3	Malin Skogvold Runestad "Towards more sustainable feed solutions in aquaculture"	Dr. Naouel Gharbi, Dr. Neda Gillanejad & Patrik Tang NORCE	In progress 2022-2024

5 Development of an MSc in Aquaculture and Fisheries course

5.1 The need

The number and breadth of new developments will require not only new thematic material but the development of a new MSc course for students who would like to deepen their knowledge in aquaculture. Currently, the existing courses are concentrated on the local systems of aquaculture based on geographic and economic issues, however, wider and deeper knowledge and competence are required by the 21st-century fish farmers and experts to be able to react and adapt to the new needs and challenges. Moreover, as it was identified during the landscape exploration stage, no specific Aquaculture MSc training exists in Hungary. The educational expertise of MATE and UiB is well placed to drive the development of such a program of study.

5.2 MSc course in Aquaculture in Hungary and Norway

Focusing on different fields related to regional expertise and skill needs of industry, MATE and UiB can realize by the combination of their unique knowledge related to the creation of programs of study (MATE – in freshwater fish aquaculture, and UiB in sea fish aquaculture), while the other project members of the tasks help to facilitate and integrate their knowledge and new technologies into the training materials.

In Hungary, this has resulted in the development of the Master's Program of Aquaculture and fisheries, which aims to train professionals who- with their acquired knowledge of fisheries management, hydrobiology, and water quality protection- can manage, supervise, and plan the production processes of aquacultures. Besides the economic aspects, they are following the recommendations of sustainable agriculture and environmental protection to find a balance between the conservation of natural resources and efficient use. Graduate students are prepared not only for starting farm or corporate-level production and management but also for continuing their studies at the Ph.D. level.

As the development of a new MSc is a huge work and a long national accreditation process, in the frame of the iFishIENCi project the MSc training concept and the lecture's academic outline can only

be developed at this time. As part of this activity, MATE-AKI submitted the concept to the competent ministry to get approval for the establishment of a new MSc course. As a next step if the Ministry approves the concept, then the University committees should approve it before accreditation can be started through the national higher education course accreditation committee. Therefore, we expect to start this new MSc training at MATE in the 2023/24 second semester in case of a successful accreditation procedure.

Currently, the list of lectures is determined (as provided in **Table 4**) for a 120-credit MSc program with 3 semesters, providing comprehensive knowledge on different areas of aquaculture. We are planning to seek approval for the new program in both Hungarian and English language, therefore the training will be available both for Hungarian and foreign students at MATE.

Table 4: List of planned lectures in the Hungarian Aquaculture MSc course

Semester	Course (lead)
1st	Fish biology and Taxonomy (Tamás Müller, PhD)
1st	Fish Genetics (Balázs Kovács, PhD)
1st	Hydrobiology (Árpád Ferincz, PhD)
1st	Fish Physiology (Miklós Mézes, PhD)
1st	Reproductive physiology of fish (Tamás Szabó, PhD)
1st	Introduction to Aquaculture (Béla Urbányi, PhD)
1st	Master Thesis Writing: Research and Publication Methodology (Ákos Horváth)
2nd	Planning and Construction for Agricultural Water Management (Zoltán Futó)
2nd	Fish Nutrition (Miklós Mézes, PhD)
2nd	Fish farming technology (Ákos Horváth, PhD)
2nd	Induced spawning and fingerling rearing of fish (Tamás Szabó, PhD)
2nd	Intensive aquaculture (Béla Urbányi, PhD)
2nd	Aquatic toxicology (Zsolt Csenki-Bakos, PhD)
2nd	Water quality protection and treatment (István Szabó, PhD)
2nd	Aquaculture economics and marketing (Emese Békefi Bozánné, PhD)
2nd	Thesis Work I (Béla Urbányi, PhD)
3rd	Protection and exploitation of surface waters (Balázs Kriszt, PhD)
3rd	Fish health and hygiene (Edit Eszterbauer, PhD)
3rd	Fish processing (László Friedrich, PhD)
3rd	Fisheries law (Tibor Csegődi)

3rd	Innovation and project management (Béla Urbányi, PhD)
3rd	Thesis Work II (Béla Urbányi, PhD)

As a next step, the outline of the lectures should be prepared according to the University rules and templates.

It was recognised that the existing landscapes of education and the needs of students and industry are different in Hungary, having no existing dedicated Aquaculture program, and Norway, having already a specific Bachelor level and 2 Master level courses available (Appendix 1). As such, in Norway a more specific approach was needed. There has been a development of the program in aquaculture to meet the stringent Norwegian industry needs. In 2018, the University of Bergen developed the "**Aquaculture Integrated Master**", which is a 5-year program (300 credits), which has 20 open spaces each year. This program is delivered in Norwegian language to meet the needs of local students. For this program, many new courses were developed, both at the entry-level bachelor-level and also up to master-level. The teaching consists of Lectures, Seminar groups, Laboratory and practical exercises, Field courses, Practice, Master thesis, and a compulsory internship which is encouraged in collaboration with members of the NCE Seafood Innovation Cluster. Courses include core biology, mathematics, statistics and chemistry, industry investigation, innovation learning and placement/internship (Table 5)

Table 5: List of Units in the Norwegian Aquaculture Integrated Master

Semester	**Course (credits)**
1st	Introduction to fish health and aquaculture (10 credits)
1st	Introduction to ecology and evolution (10 credits)
1st	User course in mathematics I (10 credits) or Mathematics for natural sciences
2nd	Biology of organisms for fish health and aquaculture (10 credits)
2nd	Basic course in programming (10 credits)
2nd	User course in mathematics II (10 credits)
3rd	Fish biology II - physiology (10 credits)
3rd	Fish biology I - systematics and anatomy (10 credits)
3rd	Basic course in mechanics and thermodynamics (10 credits) or Fish nutrition
4th	Aquaculture Technology (10 credits)
4th	Chemistry basic course (10 credits) or Food microbiology with special relevance to seafood
4th	Basic course in statistics (10 credits)
5th	Free Study Credits or exchange
6th	Environmental impact of farming (10 credits)

6th	Practice period, legislation and management in aquaculture (10 credits)
6th	Ex.phil (10 credits)
7th	Biological data analysis and experimental setup (5 credits) or Placement in a company (5 credits)
7th	Aquatic food production (10 credits)
7th	Marine Ecology (10 credits)
8th	Laboratory animal course, fish (10 credits)
8th	Commercialization and financing of technology and innovations (10 credits)
8th	Innovation in design thinking
9th & 10th	Master's Thesis

Several of these courses were also co-developed with the 5-year Fish Health professional level program, which is a very specific UiB program, where students who get this diploma have a right to prescribe prescriptions (like a veterinarian, but only with fish). This specific course meets the needs of the Norwegian educational landscape.

6 Training courses for professionals

6.1 The need

As a third pillar of the training efforts, iFishIENCi has developed special intensive training material for those experts (e.g., fish farmers, teachers of higher educational institutions, PhD students, and Postdocs). As part of the demonstration activities of the project, they have participated in field educational training, in Hungary, Crete and Malta to learn about the different aquaculture systems, the novelties, and new developments, and deepen their knowledge in practice. This training element has a strong link between the demonstration and training elements of the project.

6.2 Farmer's education program

Based on local resources and the planned activities and resources of the iFishIENCi project the following trainings were performed or planned until the end of the project.

6.2.1 African catfish breeding in SmartRAS future-farmer training, Malta

Target group: Hungarian Aquaculture students
Location: AquaBioTech Group, Malta
Timing: 14/06/2022-17/06/2022
Language: Hungarian and English
Methodology: In the summer of 2022, nine Aquaculture Master level students and their 3 supervisors from the University of MATE (Hungary) participated on a professional workshop and training courseat ABT, Malta. The travel and accommodation costs were funded by a national grant (Gant: EFOP-3.6.3-VEKOP-16-2017-00008 project) from the ERDF found of the EU. The agenda included project presentations, lecture on freshwater intensive technologies, Introduction to SmartRAS engineering, onsite training on monitoring and control systems, presentation of iFishIENCi RAS research trials on

trout, Presentation of Maltese Aquaculture with insights on circularity and digitalisation elements from iFishIENCi. Since this program, several of these students have graduated and are now working in the Hungarian industry where they are applying their knowledge to ensure the digital shift of the industry.

6.2.2 African catfish farming in Hungary, Kisbajcs, Hungary

Target group: Fish farmers
Location: Kisbajcs, Hungary
Timing: 18/01/2023
Language: Hungarian
Methodology: Farm visit at the Győri Előre Htsz. to demonstrate the benefits of the new genetic selection methods in African catfish farming and presenting the results of iFishIENCi project (lectures, Q&A session, farm visit). The aim of this training event was to support networking between African catfish producers, industry leaders and other professionals, e.g. researchers. We also aimed to present the innovations achieved in the iFishIENCi project related to the new genetic line of African catfish and to create awareness of the importance of selective breeding and selection for better feed utilization, especially for feeds produced from sustainable protein sources. Five presentations were held during the event, two of them by African catfish producers and three by researchers, covering the whole iFishIENCI project with a special focus on genetic breeding and its results, including recent studies on catfish species in general. Participants arrived from seven different African catfish producer companies, accounting for most African catfish produced in the country, as well as from a university, the Agricultural Ministry and the press, creating a special opportunity for networking in this sector. According to our knowledge this was the first event organized specially for professionals working with African catfish in this country (even though Hungary is the main producer of the species in the EU), meaning such an event was long time in demand.

6.2.3 iFishIENCi Fish Farmer Training, Gödöllő, Hungary

Target group: Fish farmers, aquaculture researchers, NGOs, aquaculture regulatory bodies
Location: Gödöllő, Hungary
Timing: 26/01/2023 – 27/01/2023
Language: English (with translation), Hungarian
Methodology: 2 days meeting; 1st day: lectures about the recent and potential applications of iFishIENCi results in the Hungarian aquaculture, Virtual farm visit at the Győri Előre Htsz. (pre-recorded video tour) to demonstrate the benefits of the new genetic selection methods in African catfish farming; 2nd day: lectures on regional issues in pond-aquaculture and angling sector; Q&A session, open discussions with experts. This event involved partners Lars Ebbeson (NORCE Norwegian Research Center), Nikos Papandroulakis (Hellenic Center for Marine Research HCMR), Tamás Bardócz (AquaBioTech Group), Balázs Kovács (MATE-AKI), Varju-Katona Milán (Bajcshal), and Márton Orbán (Vitafort) as presenters and trainers. Topics presented included- the examination of feed additives and potential raw materials in the iFishIENCi project and in other R&D programs; Innovative developments in cage aquaculture of sea bream and sea bass in Greece; The importance of digitization in Norwegian salmon farming; Opportunities of the circular economy in aquaculture based on the results of the iFishIENCi project; African catfish selection breeding program within the iFishIENCi project; and Results achieved by the iFishIENCi project at BAJCSHAL Kft.

6.2.4 iFishIENCi Aquaculture Master Student Training in Crete, Greece x2

Target Group: Future-farmers European Aquaculture Master Students
Location: Crete, Greece
Timing: March 2021 and March 2022
Language: English

Planned methodology: Through lectures and training at HCMR, Crete, 20 students at Master education level (ACES - Aquaculture Environment and Society Master). This training was implemented twice, and students were engaged in both 2022 and in 2023 for a total of 40 students. Students from this Master program go on to work across Europe and internationally in Aquaculture.

6.2.5 iFishIENCi digital innovations for Norwegian farms – Semi-closed

Target group: Fish farmers Hague Aqua
Location: Hague Aqua Ovum site, Norway
Timing: Spring 2023
Language: English/ Norwegian
Methodology: Farmers who will be implementing the iBOSS and fish-talk-to-me demos on their production sites will be given comprehensive theoretical training and hands on experience with the integration of the technologies to onsite needs, operation, interpretation, and use as a tool for optimising production in a semi-enclosed cage/pen system.

6.2.6 iFishIENCi digital innovations for Norwegian farms – open cage

Target group: Fish farmers at Hague Aqua
Location: Hague Aqua open pen site, Norway
Timing: Spring 2023
Language: English/ Norwegian
Methodology: Farmers who will be implementing the iBOSS and fish-talk-to-me demos on their production sites will be given comprehensive theoretical training and hands on experience with the integration of the technologies to onsite needs, operation, interpretation, and use as a tool for optimising production in an open cage system.

6.2.7 iFishIENCi feed development training - Serbia

Target group: Fish farmers (trout and carp) in Serbia
Timing: 23/2/2023
Language: English/ Serbian
Methodology: Organised by AAR Germany, Serbian farmers were engaged in an industrial training event discussing feed developments and improvements, feeding programmes and recommendation for trout and carp. Forty participants attended the training.

6.2.8 iFishIENCi feed utilisation training - Poland

Target group: Fish farmers (trout) in Poland
Location: Ustka, Poland
Timing: 15/3/2023
Language: English/ Polish
Methodology: Organised by AAR Germany, 45 Polish trout farmers were engaged in an industrial training event discussing the effect of high temp of farming on feeding and how functional feeds and carefully selected raw materials could improve fish health and performance.

6.2.9 iFishIENCi feed utilisation training - Denmark

Target group: Fish farmers (trout) of company Danforel
Location: Company “Danforel”, Denmark
Timing: 18/01/2023
Language: English/ Danish
Methodology: Organised by AAR Germany, 5 employees of production company Danforel, which produces trout, were engaged in an industrial training event on new raw materials and feed developments with lessons learned from iFishIENCi.

7 Conclusions

As a result of the COVID-19 pandemic, there was a major impact on the arrangement of local training and farm visits envisaged in the training concept. In the middle project years, due to the different pandemic situations of the different countries participating in the activities, in person events were not feasible. The emphasis within the project parameters was shifted in part to the development of the academic training materials and curricula that can be used efficiently in field training as well should the pandemic situation allow. This resulted in the delivery of 7 online training events organised or co-organised by the project and reaching out to industry and student participants and allowed people to continue to upskill in a time of reduced opportunities.

While in-person events were challenging, nonetheless, in the final year of the project, including the authorised extension, significant progress was made, and we were able to deliver training in-person to over 300 producers and future producers is a variety of core topics, an achievement which will echo through their professional lives. In some regions, such as Norway, where digitalisation is already well integrated, the exposure to the specific new tools will ensure the long-term interest and exploitation opportunities of the iFishIENCi KERs. In other localities such as in Hungary, participants reflected (Participants Survey WP3 and Personal Communication) that they were supporting, for the first time, the benefits that digitalisation can have for their production methods and are starting to become more open to investment in digital and sustainable technologies, an important legacy of their training.

As a further outcome, a discussion has been started about the presence and future of education in aquaculture between the different players of the sector in the frame of the annual EAS meeting in 2022 in Rimini, where several partners of the iFishIENCi project were present. This topic will be continued at the next meeting in 2023 at Vienna. The Education, training, and capacity building section (to be chaired by Prof Béla Urbányi, MATE) will continue this discussion and the results of the iFishIENCi project will be presented as well. Despite the challenges, by sharing the best practices, and experiences, thinking together, and working together, we believe that progress can be made, and new results can be achieved in this area.

8 Appendices

Appendix 1 – Higher education courses (BSc / MSc) in Aquaculture or Fishery Sciences in Europe

Country	Name of the University	MSc course name	Length	Any other important information	Links to the courses, if any
Albania	Agricultura University of Tirana, Tirana https://ubt.edu.al/en/aut/	BSc/MSc in Aquaculture and Fisheries management MP in Aquaculture Production Technologies	2 years	In Albanian language; PhD in aquaculture-related topics is also available	https://ubt.edu.al/MSC-Akuakulture.pdf https://ubt.edu.al/MP_Tekonologjite-e-prodhimit-ne-Akuakulture.pdf
Austria	Institute for Aquatic Ecology and Fisheries Management, Scharfling https://www.baw.at/en/fish-and-water/the-institute.html	MSc in Fisheries	1.5 years	Course supported by The Federal Agency for Water Management (BAW) of Austria, not every year; professional training is also available	Professional courses: https://www.baw.at/Salmoniden-Aquakultur.html
Belarus	Polessky State University, Pinsk https://www.polessu.by/	BSc in Industrial Fisheries	4 years	In Russian; PhD in Aquaculture and Fisheries is also available, as well as MSc in Food production with aquaculture issues included	MSc: https://www.polessu.by/8F BSc: https://www.polessu.by/B8
	Belarusian State Agricultura Academy, Gorki https://baa.by/	MSc in Industrial Fisheries	4 years	In Russian; PhD in Aquaculture and BSc in Aquaculture, BSc in Fish processing are available	BSc: https://baa.by/facultet/zoofac/
Belgium	Vrije Universiteit Brussel, Brussel https://www.vub.be/nl	MSc in Marine and Lacustrine Science and Management (Oceans and Lakes)	2 years	4 specializations: Biodiversity and Ecology, Conservation Biology and Ecosystem Management, Environmental Impact, Remediation Earth System Sciences	https://www.vub.be/marine-and-lacustrine-science-and-management
	Ghent University, Ghent https://www.ugent.be/en	MSc in Aquaculture	2 years	Collaboration with Tho University (Vietnam), Stellenbosch University (South-Africa) and ESPOL (Ecuador); PhD programs	https://studiekiezer.ugent.be/master-of-science-in-aquaculture-en/2022

				in Bioscience engineering: Animal Science and Aquaculture in collaboration with the Odisee (University of Applied Sciences), Belgium	
		MSc in Health Management in Aquaculture	2 years	Collaboration with Norwegian University of Science and Technology Norway; Wageningen University, Netherlands; University of Barcelona, Spain; 3 different learning lines: 1. the relationship between the ecosystem and health; 2. preventing disease and maintaining adequate health, whilst minimising the impact on the environment; 3. the relationship between animal physiology and health	https://studiekiezer.ugent.be/international-master-of-science-in-health-management-in-aquaculture-en/2022
Bosnia and Herzegovina	University of Sarajevo, Sarajevo https://www.unsa.ba/en/about-us	MSc in Aquaculture	2 years	In Bosnian language; BSc in Aquaculture is also available	
Bulgaria	Sofia University, Sofia https://www.uni-sofia.bg/eng	MSc in Applied Hydrobiology and Aquaculture	1.5 years	In Bulgarian language	https://www.uni-sofia.bg/index.php/prilozhna_hidrobiologiya_i_akvakulturi
Croatia	University of Dubrovnik, Dubrovnik https://www.unidu.hr/eng/	Eng in Mariculture	2 years	Collaboration with the University of Split	https://www.unidu.hr/mariculture-graduate/
Czechia	University of South Bohemia, České Budějovice https://www.prf.jcu.cz/en/	MSc in Fishery and Protection of Waters	2 years	BSc and PhD in Fishery are also available	MSc: https://www.frov.jcu.cz/2286 BSc: https://www.frov.jcu.cz/3046
Denmark	Technical University of Denmark (DTU), Copenhagen	MSc in Aquatic Science and Technology	2 years	3 specializations: Aquaculture, Fisheries or Oceanography	https://www.dtu.dk/aquatic-science-and-technology

	https://www.dtu.dk/english				
Estonia	Estonian University of Life Sciences, Tartu https://www.emu.ee/en/	MSc in Fisheries and Applied Ecology	2 years	Mostly in Estonian language; BSc and PhD in Fisheries and Applied Ecology are also available	
Finland	University of Helsinki, Helsinki https://www.helsinki.fi/en	MSc in Agricultural, Environmental and Resource Economics	2 years	Specialization on Fisheries and Environmental Management	https://www.helsinki.fi/agricultural-environmental-and-resource-economics-masters-programme/research
France	University of Nantes, Nantes https://english.univ-nantes.fr/	MSc in Aquaculture, Environment and Society	2 years	Joint ERASMUS Mundus program	https://sciences-techniques.univ-nantes.fr/m2-aquaculture-environment-and-society-m2-aces
Germany	Humboldt University, Berlin https://www.hu-berlin.de/en	MSc in Fish Biology, Fisheries and Aquaculture	2 years	Interdisciplinary program	https://www.agrar.hu-berlin.de/en/lehre-en/studgang-en/mfs
	University of Rostock, Rostock https://www.uni-rostock.de/	MSc in Aquaculture	2 years	Interdisciplinary program	https://www.auf.uni-rostock.de/en/study/master-dregree-program/aquaculture/program-profile/
Great-Britain	University of Stirling, Stirling, Scotland https://www.stir.ac.uk/	MScin Sustainable Aquaculture	12-27 months	Flexible course with 4 variations Aquaculture and the Environment; Aquaculture Business Management; Aquaculture and Development; Aquatic Food Security	https://www.stir.ac.uk/courses/pg-taught/aquaculture-sustainable-aquaculture/
		MSc in Aquatic Pathobiology MSc in Aquatic Veterinary Studies	12-27 months	Full-time and part-time routes available	https://www.stir.ac.uk/courses/pg-taught/aquatic-pathobiology/ https://www.stir.ac.uk/courses/pg-taught/aquatic-veterinary-studies/
	University of St Andrews, Saint Andrews, Scotland https://www.st-andrews.ac.uk/	MSc/PGDip in Sustainable Aquaculture	18-60 months	Range of part-time, e-learning, postgraduate-level modules	https://www.st-andrews.ac.uk/subjects/marine-biology/sustainable-aquaculture-msc/
	University of Plymouth, Plymouth, England	MSc in Sustainable Aquaculture	1 year	Full-time and part-time routes available	https://www.plymouth.ac.uk/courses/postgraduate/msc-sustainable-aquaculture

	https://www.plymouth.ac.uk/				
	The Scottish Association for Marine Science (SAMS), Oban, Scotland https://www.sams.ac.uk/index.html	MSc in in Aquaculture, Environment and Society	2 years	Joint ERASMUS Mundus program	https://www.sams.ac.uk/study/postgraduate/sams-aces-msc/
	University of the Highlands and Islands, Inverness, Scotland https://www.uhi.ac.uk/en/	MSc in Algal Biotechnology and Bioeconomy	1 year	BSc in Marine Science and BSc in Marine Science with Arctic Studies are also available	BSc: https://www.uhi.ac.uk/bsc-hons-marine-science/ MSc: https://www.uhi.ac.uk/msc-algal-biotechnology-and-bioeconomy/ https://www.sams.ac.uk/sams-algal-biotechnology-biology-and-ecology-mres/
		MSc in Aquaculture, Environment and Society	2 years	Erasmus Mundus Joint Master Degree	https://www.sams.ac.uk/study/postgraduate/sams-aces-msc/
Greece	University of Crete, Rethymno https://en.uoc.gr/	MSc in Aquaculture, Environment and Society	2 years	Joint ERASMUS Mundus program	
	University of Thessaly, Volos https://www.uth.gr/en	MSc in Mediterranean Aquaculture	2 years	In Greek; possible PhD in Aquaculture in English	http://pms.diae.uth.gr/
	Agricultural University of Athens, Athens https://www2.aua.gr/en	BSc in Animal Science and Aquaculture	3 years	In Greek	
Hungary	Hungarian University of Agriculture and Life Sciences, Gödöllő https://uni-mate.hu/	MSc in Agriculture	3 years	In Hungarian; the thesis topic can be chosen related to aquaculture	https://akvakultura.uni-mate.hu/en/home
Ireland	University of Galway, Galway	MSc in Marine and Freshwater Resources: Management	1 year	Interdisciplinary program	https://www.universityofgalway.ie/msc-marine-freshwater.html
Iceland	Hólar University, Sauðárkrókur https://www.holar.is/	MSc in Aquatic Biology	2 years	Including issues of Aquaculture; undergraduate courses on Aquaculture are available	https://ugla.holar.is/mscaquaculture

Italy	Università di Bologna, Bologna https://www.unibo.it/it	BSc/MSc in Aquaculture and Ichthyopathology	3 years	In Italian language; possible further education in the frame of veterinary MSc programs	https://corsi.unibo.it/laurea/acquacoltura
	Polytechnic University of Marche , Ancona https://www.univpm.it/Entra/University_1	MSc in Aquaculture	2 years	Specialization in Marine Ornamental Aquaculture; not every year	
	University of Padua, Chioggia https://www.unipd.it/en/	MSc in Marine Biology	2 years	Includes aquaculture issues of marine species	https://biologia.biologia.unipd.it/index.php?id=348
Latvia	Daugavpils University, Daugavpils https://du.lv/en/home/	MSc in Biology	2 years	Includes issues of aquaculture technologies	https://studijudala.du.lv/kursiinfo/D01BY
Lithuania	Klaipeda University, Klaipeda https://www.ku.lt/en/	MSc in Marine Biotechnology	2 years	Joint EU-CONEXUS program of the European University for Smart Urban Coastal Sustainability alliance; includes issues of Aquaculture Biotechnology	https://www.ku.lt/en/masters-degree/fall-intake-1/joint-master-in-marine-biotechnology
Malta	Malta College of Arts Science and Technology	Bachelor of Science (Honours) in Fish Management	3 years	Aquaculture and fisheries sciences production and management	https://www.mcast.edu.mt/courses/ag6-03-21/
Montenegro	University of Montenegro, Podgorica https://www.ucg.ac.me/	MEng in Technologies in Animal Production	2 years	In Croatian language; the program includes issues of aquaculture technologies	
Netherlands	Wageningen University, Wageningen https://www.wur.nl/en/wageningen-university.htm	MSc in Aquaculture and Marine Resource Management	2 years	3 specializations: Aquaculture, Marine Governance, Marine Resources and Ecology; also available PhD on Fish nutrition, Fish-environment interaction and Immunology and Vaccine Development	https://www.wur.nl/auaculture-and-marine-resource-management.htm
		MSc in Health Management in Aquaculture	2 years	Collaboration with Gent University; Norwegian University of Science and Technology,	https://www.wur.nl/en/education-programmes/master/msc-programmes/msc-health-management-aquaculture.htm

				Trondheim; University of Barcelona, Spain; 3 different learning lines: 1. the relationship between the ecosystem and health; 2. preventing disease and maintaining adequate health, whilst minimising the impact on the environment; 3. the relationship between animal physiology and health	
Norway	Norwegian University of Life Sciences, Ås https://www.nmbu.no/en	MSc in Aquaculture	2 years	3 specializations: Production Biology; Management and Farming Technology; Feed Technology and Nutrition	https://www.nmbu.no/en/studies/study-options/master/master-of-science-in-aquaculture
		MSc in Aquatic Food Production - Safety and Quality (AQFood)	2 years	Double degree master program; collaboration with The Nordic Master program; 3 study tracks: Aquatic Production, Natural Resources, Industrial Production.	https://www.nmbu.no/nordic-master-in-aquatic-food-production-safety-and-quality-aqfood
	Norwegian University of Science and Technology, Trondheim https://www.ntnu.edu/	MSc in Ocean Resources	2 years	5 specializations: Ecosystems – Biology, ecology and biogeochemistry; Aquaculture; Harvesting; Marine biochemistry and –technology; Aquatic Food science; PhD in Fisheries and Aquaculture Systems (engineering cybernetics); BSc in Aquaculture is also available	https://www.ntnu.edu/studies/msocean
		MSc in Health Management in Aquaculture	2 years	Collaboration with Gent University; Wageningen University, Netherlands; University of Barcelona, Spain; 3 different learning lines: 1. the relationship between the ecosystem and health; 2.	https://www.ntnu.edu/studies/msaquah

				preventing disease and maintaining adequate health, whilst minimising the impact on the environment; 3. the relationship between animal physiology and health	
	Nord University (University of Nordland), Bodø https://www.nord.no/en	MSc in Sustainable Production and Utilisation of Marine Bioresources	2 years	Interdisciplinary study programme in three Nordic countries (Sweden, Iceland, Norway); possible PhD in Aquatic Bioscience	https://www.nord.no/en/studies/nordic-master-in-sustainable-utilization-and-production-of-marine-bioresources
	University of Bergen, Bergen https://www.uib.no/en	Master of Science in Biology:	2 years	Aquaculture Biology, Fisheries Biology and Management and Marine Biology are specialization in the Master's Programme in Biology	https://www.uib.no/en/studies/MAMN-BIO/HAV/plan https://www.uib.no/en/studies/MAMN-BIO/FIFO/plan https://www.uib.no/en/studies/MAMN-BIO/MAR/plan
	University of Bergen, Bergen https://www.uib.no/en	Aquaculture, Integrated Masters	5 years	Closed to Norwegian students (application through the Norwegian system "Samordnaopptak")	
	University of Bergen, Bergen https://www.uib.no/en	Aquamedicine, Masters	5 years	Course in English, some courses in Norwegian; Closed to Norwegian students (application through the Norwegian system "Samordnaopptak")	https://www.uib.no/en/studies/MAMN-FISK
	University of Bergen, Bergen https://www.uib.no/en	Aquaculture Biology	2 years		
	The Arctic University of Norway, UiT Tromsø, https://en.uit.no/startsida				https://en.uit.no/startsida
Poland	University of Warmia and Mazury, Olsztyn http://www.uwm.edu.pl/en	MSc in Aquaculture and Aquaristics	1.5 years	BSc in Fisheries is also available	MSc: https://informator.uwm.edu.pl/en/prg/0603-SMU-AA_KRK/2022z/ BSc: https://informator.uwm.edu.pl/en/prg/0601-SI-RYB_KRK/2022z/

Portugal	University of Algarve, Faro https://www.ualg.pt/en	MSc in Aquaculture and Fisheries	2 years	PGDip and PhD in Aquaculture are also available	https://www.ualg.pt/en/curso/1430
		MSc in Marine, Biodiversity, Fisheries and Conservation	2 years	Including issues of mariculture	https://www.ualg.pt/en/curso/1933
	University of Porto, Porto https://www.up.pt/portal/en/	MSc in Biological Aquatic Resources	2 years	Including questions of aquaculture and fisheries; PhD in Aquaculture is also available	https://www.up.pt/portal/en/study/masters-degrees/courses/fcup/959/
Romania	"Dunărea de Jos" University of Galati, Galati https://www.en.ugal.ro/	MSc in Aquatic Bioresources Science and Engineering	2 years	In Romania language; BSc in Fish Farming and Aquaculture is also available	
Russia	Astrakhan State Technical University, Astrakhan https://astu.org	MSc/PhD in Aquaculture	2/3 years	In Russian; BSc in Water bioresources and Aquaculture is also available; 2 directions: Sustainable Management of Water Bioresources; Aquaculture	https://astu.org/Content/PageInstitute/3440#anchor
	Astrakhan State University, Astrakhan https://asu.edu.ru/en	MSc in Hydrobiology and Aquaculture	2 years	In Russian; BSc and PhD in Water bioresources and Aquaculture are also available, as well as different short time professional programs and Sturgeon Aquaculture and Ichthyopathology PGDips	
	Saratov State Vavilov Agrarian University, Saratov https://en.sgau.ru/	MSc in Sturgeon Aquaculture	2 years	In Russian; BSc Water Bioresources and Aquaculture is also available	BSc: https://www.vavilovsar.ru/111400-62-vodnye-bioresursy
	Volgograd State Agriculture University, Volgograd https://volgau.com/	BSc/PGDip/SpD in Water Bioresources and Aquaculture	4-2-4 years	In Russian; Two directions: Fisheries, Management of Water bioresources	https://volgau.com/B0
	Razumovsky Moscow State University of Technologies and Management, Moscow https://mgutm.ru/en/	MSc in Management of RDI in Aquaculture	2 years	In Russian, BSc in Aquaculture is also available; 4 different learning lines: Aquaculture Technologies, Ecological Engineering in Sustainable Aquaculture, Research in Aquaculture and Ichthyology, Aquaculture	https://mgutm.ru/en/np/vodnye-bioresursy-i-akvakultura/

	P.A. Stolypin Ulyanovsk State Agrarian University, Ulyanovsk https://ulsau.ru/eng/	BSc in Water Bioresources and Aquaculture	4 years	In Russian; a 5 years distant program is available	
	Dmitrov Fisheries Technical Institute, Dmitrov https://дрти.рф/	BSc in Water Bioresources and Aquaculture	4 years	In Russian; various short professional programs are also available	
	Smolensk State Agricultural Academy, Smolensk https://sgsha.ru	BSc in Water Bioresources and Aquaculture	4 years	In Russian	
	Voronezh State University of Engineering Technologies, Voronezs https://vsuet.ru/	BSc in Water Bioresources and Aquaculture	4 years	In Russian; various short professional programs are also available	
	Saint Petersburg State Agrarian University, Saint Petersburg https://inter.spbgau.ru/en	SpD in Water Bioresources and Aquaculture	5 years	In Russian but some courses/program parts are available in English	
	Russian State Hydrometeorological University, Saint Petersburg https://www.rshu.ru/eng/	SpD in Water Bioresources and Aquaculture Management	5 years	In Russian; PGDip in Aquaculture is also available, including in English	
	Saint Petersburg State University of Veterinary Medicine, Saint Petersburg https://spbguvm.ru/#	MSc in in Water Bioresources and Aquaculture	2 years	In Russian and English; BSc in Water Bioresources and Aquaculture is also available	
	Sakhalin State University, Yuzhno-Sakhalinsk http://sakhgu.ru/	MSc in and Aquaculture	2 years	In Russian; distant and digital education is available; there are also BSc in Aquaculture and PhD in Ichthyology programs	
	Dagestan State Agrarian University, Makhachkala https://дагray.рф/	BSc in Water Bioresources and Aquaculture	4 years	In Russian; professional short-time programs are also available	https://дагray.рф/images/docum_svedenia/obrazovanie/bio_fakultet/op/350308_op_vod_biores_2020.pdf

	Petrozavodsk State University, Petrozavodsk https://petrsu.ru/en	MSc in in Water Bioresources and Aquaculture	2 years	In Russian and English; BSc is also available	BSc: https://petrsu.ru/docs/counter/1152 MSc: https://petrsu.ru/docs/counter/7912
	Chelyabinsk State University, Chelyabinsk https://www.csu.ru/en	BSc in Water Bioresources and Aquaculture	4 years	In Russian; professional short-time programs are also available	https://www.csu.ru/Shared%20Documents/sveden/study_plans/ecol/UP_35.03.08_UVBiA_o_2022.pdf
	Irkutsk State Agrarian University, Irkutsk https://irsau.ru/	BSc in Fish Protection and Fisheries	4 years	In Russian	
	Kaliningrad State Technical University, Kaliningrad https://www.klgtu.ru/en/	MSc in Water Bioresources and Aquaculture	2 years	In Russia and English; BSc and PhD are also available	https://www.klgtu.ru/upload/education/opb/opvo/mag/vam/35_04_07_up_eng.pdf in English
	Kazan State Power Engineering University, Kazan https://kgeu.ru/	MSc in Aquaculture	2 years	In Russian; BSc in Water Bioresources and Aquaculture is also available	https://kgeu.ru/Education/EduProfil/3?idProfil=523 in English
	Novosibirsk State Agrarian University, Novosibirsk https://nsau.edu.ru/en/	MSc in Aquaculture	2 years	In Russian; BSc in Water Bioresources and Aquaculture is also available	https://nsau.edu.ru/en/education/programs/mast/bio_techno/ in English
	Kuban State University, Krasnodar https://www.kubsu.ru/	MSc in Aquaculture	2 years	In Russian; BSc in Water Bioresources and Aquaculture is also available	
	Murmansk State Technical University, Murmansk https://www.mstu.edu.ru/	MSc in Marine Bioresources and Mariculture	2 years	BSc in Aquaculture in Artic Region is also available	
	Kamchatka State Technical University, Petropavlovsk-Kamchatskiy https://kamchatgtu.ru/	MSc in Aquaculture	2 years	In Russian; BSc and SpD in Aquaculture are also available	
	The Far Eastern State Technical Fisheries University, Vladivostok https://dalrybvtuz.ru/	MSc in Aquaculture Management MSc in Marine Fisheries	2 years	BSc in Water Bioresources and Aquaculture and BSc in Ichthyology are also available	
	Don State Technical University, Rostov-on-Don	MSc in Aquaculture	2 years	There are also three BSc courses: Fish Genetics, Aquaculture	

	https://donstu.ru/en/			Engineering, Aquaculture; distant education programs are also available	
Scotland	University of Sterling	Msc in Sustainable Aquaculture, Aquatic Pathobiology, Aquatic Veterinary Studies	1–3 years	Sustainable Aquaculture, Aquatic Pathobiology, Aquatic Veterinary Studies	https://www.stir.ac.uk/about/faculties/natural-sciences/aquaculture/study/
	University of St. Andrews	Sustainable Aquaculture – distance learning (PGDip/MSc)	18 months–5 years	Minimum 18 months part-time, maximum four years part-time (PGDip); minimum two years part-time, maximum five years part-time (MSc) . The PGDip/MSc in Sustainable Aquaculture offers a range of part-time, e-learning, postgraduate-level modules which aim to develop students' critical understanding of the development and principles of aquaculture. The PGDip/MSc in Sustainable Aquaculture offers a range of part-time, e-learning, postgraduate-level modules which aim to develop students' critical understanding of the development and principles of aquaculture.	https://www.st-andrews.ac.uk/subjects/marine-biology/sustainable-aquaculture-msc/
Spain	Universidade Santiago de Compostela, Santiago de Compostela https://www.usc.gal/en	MSc in Aquaculture	1 year	In Spanish language; collaboration with University of A Coruña and University of Vigo	https://www.usc.gal/en/studies/masters/science/master-aquaculture

	University of Barcelona, Barcelona https://www.ub.edu/web/portal/en/	MSc in Aquaculture	18-24 months	Collaboration with Autonomous University of Barcelona and Technical University of Catalonia; PhD in Aquaculture is also available	https://www.ub.edu/M0604/index.html https://www.ub.edu/288365
		MSc in Health Management in Aquaculture	2 years	Collaboration with Gent University; Norwegian University of Science and Technology, Trondheim; Wageningen University, Netherlands; 3 different learning lines: 1. the relationship between the ecosystem and health; 2. preventing disease and maintaining adequate health, whilst minimising the impact on the environment; 3. the relationship between animal physiology and health	https://www.ub.edu/10187421
	Polytechnic University of Valencia, Valencia http://www.upv.es/en/	MSc in Aquaculture	1 year	In Spanish language; collaboration with Technical University of Valencia	http://www.upv.es/titulaciones/MUA/indexi.html
	University of Vigo, Vigo https://www.uvigo.gal/en	MSc in Marine Aquaculture	1.5 years	In Spanish language	https://www.uvigo.gal/acuicultura-v02m102v03
	University of Las Palmas de Gran Canaria, Las Palmas de Gran Canaria https://www.ulpgc.es/	MSc in Sustainable Management of Fishing Resources	1 year	In Spanish language	
		MSc in Marine Aquaculture	2 years	In collaboration with CIHEAM Zaragoza	
	University of Cadiz, Cádiz https://www.uca.es/?lang=en	MSc in Aquaculture and Fishing	1 year	In Spanish language	
Sweden	Swedish University of Agricultural Sciences, Umeå https://www.slu.se/en	MSc Conservation and Management of Fish and Wildlife	2 years	PhD in Aquaculture is also available	https://www.slu.se/management-of-fish-and-wildlife-populations

	University of Gothenburg, Göteborg https://www.gu.se/en	MSc in Sustainable Production and Utilization of Marine Bioresources	2 years	Interdisciplinary study programme in three Nordic countries (Sweden, Iceland, Norway)	https://www.gu.se/nordic-masters-programme-in-sustainable-production-and-utilization-of-marine-bioresources-n2mab
Turkey	Ankara University, Ankara https://www.ankara.edu.tr/en/	Msc in Fisheries and Aquaculture Engineering	2 years	In Turkish language; BSc Fisheries and Aquaculture course in English are available, as well as short professional trainings	http://bbs.ankara.edu.tr/Amac_Hedef.aspx?bno=3936&bot=1508
	Istanbul University, Istanbul https://www.istanbul.edu.tr/en/	MSc in Aquaculture MSc in Fish Diseases	2 years	In Turkish with some courses in English; BSc/PhD in Aquaculture are also available, as well as short professional trainings	https://ebs.istanbul.edu.tr/home/program?id=12376 https://ebs.istanbul.edu.tr/home/program?id=12374
	Aydin Adnan Menderes University, Aydin https://www.adu.edu.tr/en/	MSc in Aquaculture	2 years	In Turkish language	
Ukraine	Odessa State Environmental University, Odessa https://odeku.edu.ua/	MSc in Aquatic Bioresources and Aquaculture	16 months	In Ukrainian; BSc in Aquaculture and short professional programs are also available	https://odeku.edu.ua/wp-content/uploads/207_vbr_90_inoz_22-23.pdf
	Stepan Gzhytskyi National University of Veterinary Medicine and Biotechnologies of Lviv, Lviv http://us.lvet.edu.ua/	MSc in Aquatic Bioresources and Aquaculture	16 months	In Ukrainian; BSc in Aquatic Bioresources and Aquaculture is also available	
	National University of Life and Environmental Sciences of Ukraine, Kyiv https://nubip.edu.ua/en	MSc in Sturgeon Fish Farming MSc in Pond Fish Farming MSc in Selection of Fish Farming Facilities	16 months	In Ukrainian with some parts in English; BSc/PhD in Aquaculture are also available	https://nubip.edu.ua/node/1173/5 https://nubip.edu.ua/node/1173/4
	National University of Water and Environmental Engineering, Rivne https://nuwm.edu.ua/en/	MSc in Artificial Reproduction and Rational Use of Aquatic Bioresources	16 months	In Ukrainian; BSc in Aquatic Bioresources and Aquaculture is also available	https://start.nuwm.edu.ua/bakalavr/item/vodni-bioresursy-ta-akvakultura-okhorona-vidtvorennia-ta-ratsionalne-vykorystannia-hidrobioresursiv

	Dnipro State Agrarian and Economic University, Dnipro https://www.dsau.dp.ua/en/	MSc in Aquatic Bioresources and Aquaculture	16 months	In Ukrainian; BSc in Aquatic Bioresources and Aquaculture is also available	https://drive.google.com/file/d/13ILxhPS_mZT_8J8aUgi1bgfxi-hW8zWg/view
	Vinnytsia National Agrarian University, Vinnytsia https://vsau.org/en	MSc in Aquatic Bioresources and Aquaculture	16 months	In Ukrainian; BSc in Aquatic Bioresources and Aquaculture is also available	
	Kherson State Agrarian and Economic University http://www.ksau.kherson.ua/	MSc in Aquatic Bioresources and Aquaculture	16 months	In Ukrainian; BSc in Aquatic Bioresources and Aquaculture is also available, as well as some short professional programs	http://www.ksau.kherson.ua/80_2021.pdf
ERASMUS MUNDUS JOINT MASTERS DEGREE	University of Crete (Co-ordinator); University of the Highlands and Islands (Scottish Association for Marine Science); University of Nantes; Radboud University	Aquaculture, Environment and Society Start	2 years	The Erasmus Mundus Joint Master Degree in AquaCulture, Environment and Society-STAR (EMJMD ACES-STAR) is a 120-ECTS course that runs for two years. During the first 3 semesters of the programme, students will study in a different EU country. To ensure course and group integration, the entire cohort of students will re-locate to different universities and institutes during these semesters.	https://www.emm-aces.org/

Andorra, Cyprus, Kosovo, Liechtenstein, Luxembourg, Moldova, Monaco, North Macedonia, San Marino, Serbia, Slovenia, Slovakia, Switzerland, Vatican – **No specific aquaculture education is currently available**

Appendix 2 – List of relevant Subjects of MATE where iFishIENCi short materials will be implemented as part of existing lectures.

Identifier	Subject title	Lead	Credits	Hours/ semester	Semester	Course
SMKHG5016AN	Basics of fish farming and aquaculture	Dr Béla Urbányi	3	26	spring	MSc in Agricultural engineering
AKVKB001L	The economics of fish farming	Dr Béla Urbányi	5	24	spring	Advanced course (with MSc)
SMKHG2A16AN	Intensive Fish Culture	Dr Béla Urbányi	3	26	spring	BSc students
AKVKB014L	Fish biotechnology-genome manipulation in fish	Dr Balázs Kovács	3	24	spring	MSc in Agricultural Biotechnology
SMKHG2016MN	Traditional and alternative fish farming systems	Dr Árpád Hegyi	3		spring	BSc in Agricultural Engineering
AKVKB004L	Aquaculture and intensive fish farming	Dr Ákos Horváth	5	24	autumn	Advanced course (with MSc)
AKVKB017N	Fish management	Dr Árpád Hegyi	3	39	autumn	Advanced course (with MSc)
AKVKB023N	Fish genomics	Dr Balázs Kovács	3	26	autumn	MSc in Agricultural Biotechnology
AKVKB079N	Intensive fish farming in closed systems	Dr Béla Urbányi	5	26	autumn	PhD subject
AKVKB092N	Detailed fish economics	Dr László Horváth/ Dr Tamás Müller	5	26	autumn	PhD subject