BlueAquaEdu

D2.1 – The BlueAquaEdu educational activities map

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DELIVERABLE NAME	
ID: 2.1	**The BlueAquaEdu educational activities map**
Work Package No.	**WP2. Establishment of the virtual Aquaculture Educational (v-AquaEdu) Network**
Lead Beneficiary	AUA
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Type	R — Document, report
Dissemination Level	PU - Public
File	BlueAquaEdu_D2.1
Revision	v1
Due Date	30.04.2024
Submission Date	28.05.2024
Call Document	EMFAF-2023-BlueCareers — Blue careers for a sustainable blue economy
EU Grants	Call document (EMFAF): V1.0 – 13.10.2022
Grant Agreement	**101124699**

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DOCUMENT HISTORY

Revision No.	Revision Date	Modification	Authors
V0	29.02.2024	Document creation	George TRIANTAPHYLLIDIS, Helen MILIOU, Evanthia CHATZOGLOU (AUA); Manon DESMYTTER, Marie BRUAUT, Sullivan Halipré, Lisa WACSIN (AQUIMER); Anna POLLANI (MINDS), Anastasios BALTADAKIS, Savvas CHATZINIKOLAOU (LAMAR); Achilleas LEKKAS, Diogo THOMAZ (InnovaSea); Patrícia CANHÃO, Joao RITO (SeaEntia); Subriena BAKSH, Eric LAFONTAINE (GDI).
V1	28.05.2024	First version	AUA

CLASSIFICATION

This document is:

Draft	
Final	**X**
Public	**X**
Restricted	
Sensitive	

The **BlueAquEdu** Project is co-financed by the European Climate, Infrastructure and Environment Executive Agency (CINEA) with Grant Agreement 101124699

Summary/ Abstract

Aquaculture education in Europe is evolving to meet the challenges and opportunities of the 21st century. From traditional fish farming to cutting-edge RAS and aquaponics systems, from basic skills training to advanced research degrees, aquaculture education offers a pathway to sustainable development, economic prosperity, and environmental stewardship. By investing in education, research and innovation, Europe position itself as a global leader in aquaculture education and contribute to a more prosperous and sustainable future for all.

This deliverable D2.1 provides details for the offering of aquaculture education in 18 European Countries and 5 French Outermost Regions of the Atlantic Ocean distributed in 3 main categories (Vocational Training, Bachelor's Degrees and Master's degrees) where different aquaculture practices are taking place, different consumption habits define the seafood market and employability in the sector. Overall, 234 establishments have been identified offering aquaculture education in Europe and in the French Outermost Regions (OR) of the Atlantic Ocean. 45 establishments are offering vocational training (19%), 93 are offering first cycle-Bachelor studies (40%) and 96 are offering second cycle - Master's degrees (41%). The majority of these establishments are public (215), 8 are private, 1 is private/public and for 10 of them their status is not clear. France has the higher number of establishments (40), followed by Greece (35) and Italy (34). No establishments have been recorded in Cyprus and the French OR of Martinique, Mayotte and Reunion.

The purpose of this deliverable is to create a network of aquaculture education providers. This network will be used to enhance collaboration, share best practices and foster innovation in aquaculture education across Europe and the French OR. This summary highlights the extensive and varied offerings in aquaculture education, underscoring the importance of continued investment and development in this vital sector.

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1 Aquaculture Education in Europe

1.1 Introduction

Aquaculture is the cultivation of aquatic organisms such as fish, shellfish and aquatic plants. It plays a crucial role in meeting the growing global demand for seafood while contributing to economic growth, food security and environmental sustainability. In Europe, where marine and freshwater resources are abundant, aquaculture education serves as a cornerstone for the sustainable development of the Blue Economy. In numerous Member States, the aquaculture sector has stood out as a leading contributor to industrial expansion in the last decades. During the past 50 years European aquaculture has witnessed substantial growth in the production volumes of both fish and shellfish, coupled with a notable surge in the adoption of technological advancements within aquaculture operations. This trend has instilled a growing sense of confidence within the industry, firmly establishing modern fish farming as a significant player within the broader food industry landscape.

The roots of aquaculture education in Europe can be traced back centuries, with traditional practices such as fish farming and pond culture prevalent in many regions. However, formalized education and training programs in aquaculture emerged in the 20th century in response to the increasing industrialization and commercialization of the sector. Early efforts focused on basic techniques and knowledge transfer, often within agricultural or fisheries schools. Over time, as the aquaculture industry evolved and diversified, educational institutions began offering specialized programs tailored to the needs of different aquaculture sectors, including marine, freshwater and aquaponics.

Over the past decades, the landscape of aquaculture in Europe has undergone notable changes, particularly in terms of species diversification. Initially, aquaculture operations in Europe were centred on a limited number of traditionally farmed species, including trout, carp, oysters, mussels and salmon. However, significant efforts in research and development, backed by support from EU and national policies, have been directed towards expanding the range of species cultivated. This diversification aims to enhance economic stability, promote sustainable resource utilization and bolster overall industry resilience.

As a result, Europe has witnessed the successful progression of several new finfish species into large-scale intensive farming. Species such as European sea bass, gilthead sea bream, turbot and meagre have seen increasing volumes of production. Concurrently, ongoing research efforts are paving the way for the emergence of additional species from the research and development pipeline. Examples include Arctic char, sea trout, sturgeon, various sparids and cod, as solutions are found to fundamental biological and husbandry challenges. In essence, the diversification of aquaculture species in Europe signifies a dynamic shift in the industry landscape, driven by innovation, sustainability goals and evolving market demands.

However, alongside these positive developments, there have emerged certain challenges and concerns. One notable issue is the discrepancy between production levels and market demand, leading to supply chain imbalances. Additionally, there has been widespread attention drawn to the environmental impacts associated with intensified aquaculture practices. These concerns encompass various aspects such as habitat degradation, water pollution, and ecosystem disruption. Moreover, the rapid expansion of aquaculture has brought to light the heightened risk of infectious diseases within aquatic populations. This proliferation of

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diseases is attributed to a range of causative agents, including various microorganisms and parasites, posing significant threats to both aquatic animal welfare and industry sustainability.

Today, aquaculture education in Europe encompasses a wide range of academic degrees, postgraduate studies, vocational training programs and continuing education opportunities. These programs are offered by universities and vocational schools often in cooperation with research institutes, industry associations and local municipalities, reflecting the interdisciplinary nature of aquaculture and its integration with other fields such as biology, engineering, economics and environmental science.

At the university level, undergraduate and postgraduate degrees in aquaculture cover topics such as aquaculture production systems, aquatic biology, water quality management, aquaculture economics, and sustainable aquaculture practices. Students may pursue degrees in aquaculture-specific disciplines or enrol in related programs such as marine biology, fisheries science, or environmental management with a focus on aquaculture.

At the University level, undergraduate courses related to Aquaculture are included in study programs of Biology, Ichthyology, Marine Science, Animal Science and Veterinary degrees, offering a broad knowledge related to ichthyology, fish physiology, marine environment e.t.c. Post graduate Master degrees offer more specialised courses, such as aquaculture production systems, aquatic biology, water quality management, aquaculture economics, and sustainable aquaculture practices and are often included in marine biology, fisheries science, or environmental management programs

Vocational training programs provide hands-on skills and practical experience for individuals seeking employment in various aquaculture sectors, including fish farming, hatchery operations, aquaponics, seafood processing, and aquaculture management. These programs often involve internships or apprenticeships with aquaculture businesses and emphasize industry-relevant competencies and certifications.

In addition to formal education programs, aquaculture professionals in Europe have access to a wide range of continuing education and professional development opportunities. These include workshops, seminars, conferences, online courses and certifications offered by industry organizations, government agencies and academic institutions. Topics covered may include emerging technologies, best management practices, and regulatory compliance and market trends.

As Europe strives to achieve its goals of sustainable development and economic growth in the Blue Economy, aquaculture education will continue to play a vital role in preparing the next generation of aquaculture professionals and innovators. By fostering a culture of lifelong learning, interdisciplinary collaboration and innovation, aquaculture education in Europe will contribute to the prosperity of coastal communities, the health of aquatic ecosystems, and the resilience of global food systems.

Despite the growth and diversification of aquaculture education in Europe, several challenges persist. These include limited funding and resources for education and research, outdated curricula that do not always align with industry needs and a shortage of qualified instructors and industry experts. Additionally, the COVID-19 pandemic has disrupted traditional educational models and highlighted the need for innovative approaches to teaching and learning in aquaculture.

However, despite these challenges, there are also significant opportunities for innovation and collaboration. Advances in technology, such as remote sensing, automations and data analytics, are transforming

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aquaculture practices and creating demand for new skills and knowledge. Interdisciplinary research initiatives are addressing complex challenges related to environmental sustainability, animal welfare, disease management and food safety. And partnerships between academia, industry and government are fostering knowledge exchange, technology transfer and workforce development across the aquaculture value chain.

This deliverable marks the commencement of Task 2, which aims to delineate and chart educational initiatives targeting the cultivation of essential competencies and qualifications across various professions within the aquaculture Blue Economy sector. These professions encompass roles in hatcheries, cage farms, RAS (Recirculating Aquaculture Systems), processing and valorisation. Leveraging insights garnered from prior pertinent projects in the region, such as MENTOR's "Blue Career Centre for Eastern Mediterranean & Black Sea" and "EU-CONEXUS RFS," **BlueAquaEdu** endeavours to facilitate the transferability of findings to other geographic locations. Collaboratively, partners undertook the task of identifying and mapping all accredited training programs—both academic degrees and vocational trainings—within the region, including those offered by the consortium members themselves.

This Deliverable, D2.1, constitutes a mapping exercise of the existing training programs in Europe. It is a comprehensive survey targeting universities and vocational education and training (VET) providers in aquaculture. The survey focused on gathering information from each **BlueAquaEdu** country as well as selected EU and European countries. The overarching goal is to establish a robust network for dissemination purposes and to foster a broader Blue network that facilitates the creation of synergies with the **BlueAquaEdu** e-platform.

1.2 Methodology overview

1.2.1 Matrix for data collection

A matrix for mapping the aquaculture education activities has been created to better understand the types of education offered and gather relevant information for analysis. To systematically organize the gathered data for analysis, a structured matrix was devised using Excel. This matrix encompassed several key fields to provide a detailed overview of each educational entity:

1. **Type of Organisation:** Categorized as University, Vocational Education and Training (VET), or Public Authority.
2. **Type of Education Provided:** Including Higher Education, Vocational Training, or Other forms of educational offerings.
3. **Legal Status:** Classified as Public, Private, or Other legal status.
4. **Location:** City where the institution is based.
5. **Country:** The country where the institution operates.
6. **Level of Education and Training Provided:** Indicated using the International Standard Classification of Education (ISCED) levels ranging from 3 to 8, along with an option for Other.
7. **Responsible Department:** Identifying the specific school, faculty, or department overseeing the courses.
8. **Education and Training:** Listing the titles of relevant courses and curricula offered.
9. **Undergraduate Programme:** Details of undergraduate study programs.
10. **ECTS Credits for Graduation:** Total European Credit Transfer and Accumulation System (ECTS) credits required for graduation.
11. **Postgraduate Programme Title:** Titles of postgraduate study programs.

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12. **ECTS for Postgraduate Diploma:** ECTS credits associated with postgraduate diplomas.
13. **Language of Instruction:** Language(s) used for postgraduate studies.
14. **Postgraduate Programme Details:** Further information on postgraduate study programs.
15. **Contact Person:** Name and surname of the individual responsible for communication.
16. **Role within the Organisation:** Describing the position or role of the contact person within the institution.
17. **Contact Email:** Email address for communication.
18. **Contact Telephone Number:** Telephone contact details.
19. **Website:** Web address for the institution.

1.2.2 Data collection method

The partners embarked on an extensive data collection effort, employing both online surveys and direct exploration of institutional websites. This multifaceted approach aimed to comprehensively capture information on aquaculture education activities across various types of organizations and included:

- Online databases and directories of universities, vocational training centres, and public authorities.
- Websites of individual institutions offering aquaculture education.
- Government or ministry websites providing information on accredited education providers.
- Professional associations or networks in the aquaculture industry.

This approach to data collection and organization ensured that a comprehensive dataset was compiled, facilitating thorough analysis and understanding of aquaculture education activities across different institutions.

1.2.3 Geographical scope

The partners AUA, AQUIMER, GDI, InnovaSea, LAMAR, MINDS and SeaEntia have contributed to data collection with extensive surveys in the internet and visiting the web sites of the Institutions identified. The following Table summarise the responsible partner for the surveys.

Table 1. The Countries that have been surveyed for offering aquaculture training and education and the responsible partner for the surveys.

Country	Responsible partner
Belgium	LAMAR
Bulgaria	MINDS
Croatia	AQUIMER
Cyprus	AUA
Denmark	InnovaSea
Finland	AQUIMER
France	AQUIMER
French Guiana	GDI
Germany	InnovaSea
Greece	AUA
Guadeloupe	GDI
Italy	AUA

Country	Responsible partner
Ireland	LAMAR
Malta	MINDS
Martinique	GDI
Mayotte	GDI
Norway	InnovaSea
Poland	SeaEntia
Portugal	SeaEntia
Reunion	GDI
Romania	SeaEntia
Spain	MINDS
The Netherlands	LAMAR

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1.2.4 International Standard Classification of Education (ISCED)

Education systems vary significantly across nations, making it crucial to establish an international framework that enables the comparison of educational programs on a global scale. To address this need, UNESCO developed the ISCED classification, or the International Standard Classification of Education, during the mid-1970s. Initially revised in 1997, ISCED underwent further refinement between 2009 and 2011 through comprehensive consultations involving countries, regional experts, and international organizations. This collaborative effort led to the adoption of ISCED 2011 by the UNESCO General Conference in November 2011, providing a standardized framework for categorizing education levels worldwide.

Nowadays, ISCED is the reference international classification for organising education programmes and related qualifications by levels and fields. ISCED 2011 (levels of education) has been implemented in all EU data collections since 2014. ISCED-F 2013 (fields of education and training) has been implemented since 2016.

1.2.5 European Credit Transfer and Accumulation System (ECTS)

The European Credit Transfer and Accumulation System (ECTS) serves as a vital tool within the European Higher Education Area, facilitating transparency in studies and courses. Its primary aim is to streamline the process for students transitioning between countries and ensure the recognition of their academic qualifications and study periods abroad. By allowing credits earned at one higher education institution to be transferable towards a qualification pursued at another, ECTS promotes the recognition of learning outcomes and associated workload. This standardized approach not only supports the mobility of students but also fosters flexibility in study programs, aiding in their planning, delivery and evaluation.

Integral to the Bologna Process, ECTS plays a pivotal role in aligning national education systems internationally. Moreover, it simplifies the use of complementary documents like the Diploma Supplement across different countries. While widely adopted within the European Higher Education Area, ECTS is increasingly recognized and utilized beyond its borders. Its necessity arises from the disparities among national higher education systems, which can impede the recognition of qualifications and periods of study abroad. By enhancing comprehension of learning outcomes and workload, ECTS addresses these challenges and accommodates diverse learning styles, including work-based learning and lifelong learning.

Practically, ECTS operates on a credit system where 60 credits correspond to a full year of study or work. These credits are typically distributed across various modules within an academic year. Short cycle qualifications typically require 90-120 ECTS credits, while bachelor's degrees consist of either 180 or 240 credits. Similarly, master's degrees typically range from 90 to 120 ECTS credits. At the Ph.D. level, the application of ECTS may vary.

To facilitate student mobility, institutions utilize course catalogues, Learning Agreements and Transcripts of Records, which document and recognize credits earned during study periods abroad. For comprehensive guidance on the system's implementation, the ECTS Users' Guide[1] offers detailed information.

[1] See: ECTS users' guide 2015. https://op.europa.eu/en/publication-detail/-/publication/da7467e6-8450-11e5-b8b7-01aa75ed71a1

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2 The analysis of the aquaculture training and education in Europe

Overall, 234 establishments have been identified offering aquaculture education in Europe and in the French Outermost Regions (OR) of the Atlantic Ocean (see Table 2).

Table 2. The distribution of aquaculture training and education in 18 European Countries and 5 French Outermost Regions of the Atlantic Ocean distributed in 3 main categories (Vocational Training, Bachelor's Degrees and Master's degrees).

Country	Vocational Training	Bachelor's Degrees	Master's degrees	Total
Belgium			3	3
Bulgaria	1	2	2	5
Croatia		1	4	5
Cyprus				0
Denmark			2	2
Finland	2		2	4
France	15	10	15	40
Germany			2	2
Greece	8	19	8	35
Italy	8	11	15	34
Ireland		3	3	6
Malta		4		4
Norway			6	6
Poland	3	6	6	15
Portugal	3	11	7	21
Romania	0	7	8	15
Spain	5	17	11	33
The Netherlands		2	2	4
French Guiana	2			
Martinique				
Mayotte				
Reunion				
Guadeloupe		1	0	1
	45	**93**	**96**	**234**

45 establishments are offering vocational training (19%), 93 are offering first cycle-Bachelor studies (40%) and 96 are offering second cycle - Master's degrees (41%) (Figure 1).

The majority of these establishments are public (215), 8 are private, 1 is private/public (Université de Bretagne Occidentale – Agrocampus) and for 10 of them their status is not clear.

France has the higher number of establishments (40), followed by Greece (35) and Italy (34). No establishments have been recorded in Cyprus and the French OR of Martinique, Mayotte and Reunion.

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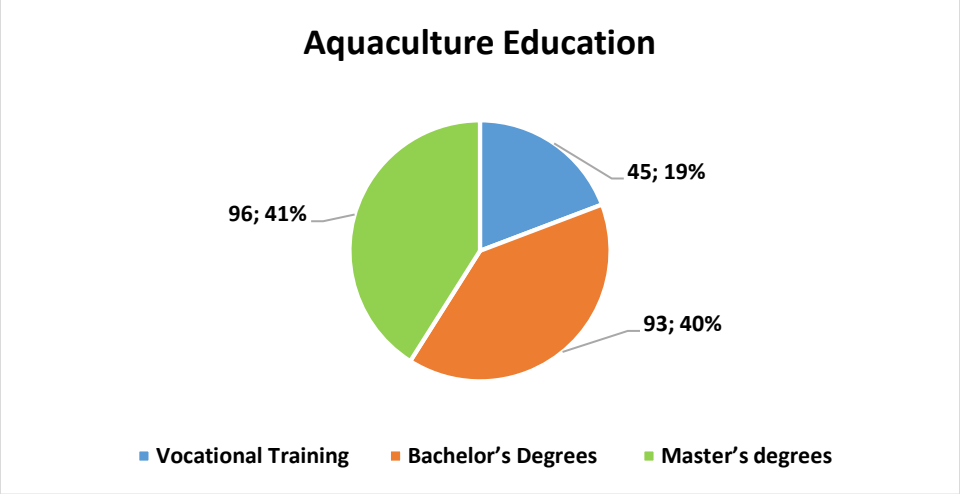
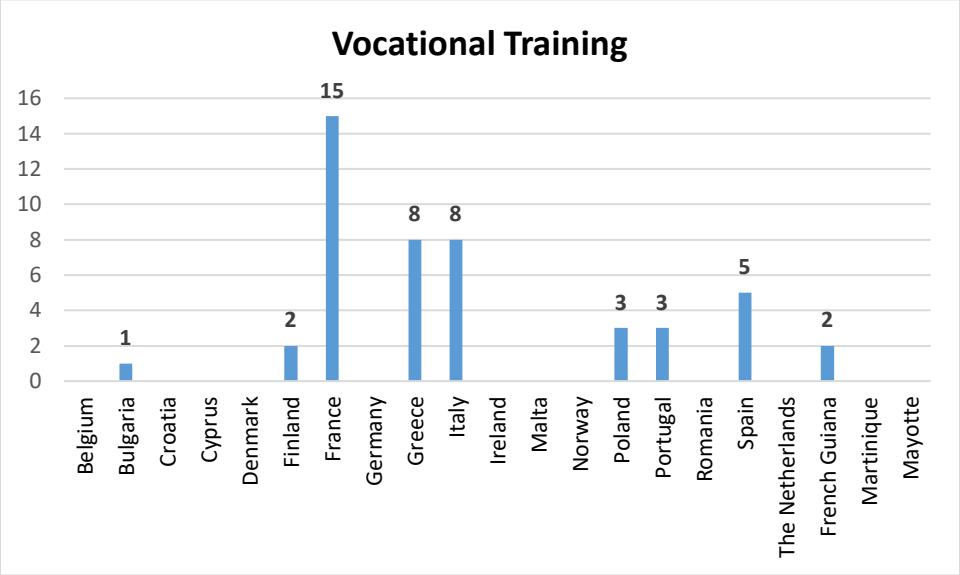
Figure 1. Aquaculture education in Europe and the French Outermost Regions of the Atlantic Ocean surveyed for the **BlueAquaEdu** Project.



2.1 Vocational training

From the vocational establishments recorded, the higher number is in France (15), followed by Greece and Italy (8). No establishments have been recorded in Belgium, Croatia, Cyprus, Denmark, Germany, Ireland, Malta, Norway, the Netherlands and the French OR of Martinique, Mayotte, Reunion and Guadeloupe. However these numbers may vary, as some vocational training offers are available for a specific time frame.

Figure 2. Vocational training for Aquaculture in Europe and the French Outermost Regions of the Atlantic Ocean surveyed for the **BlueAquaEdu** Project.



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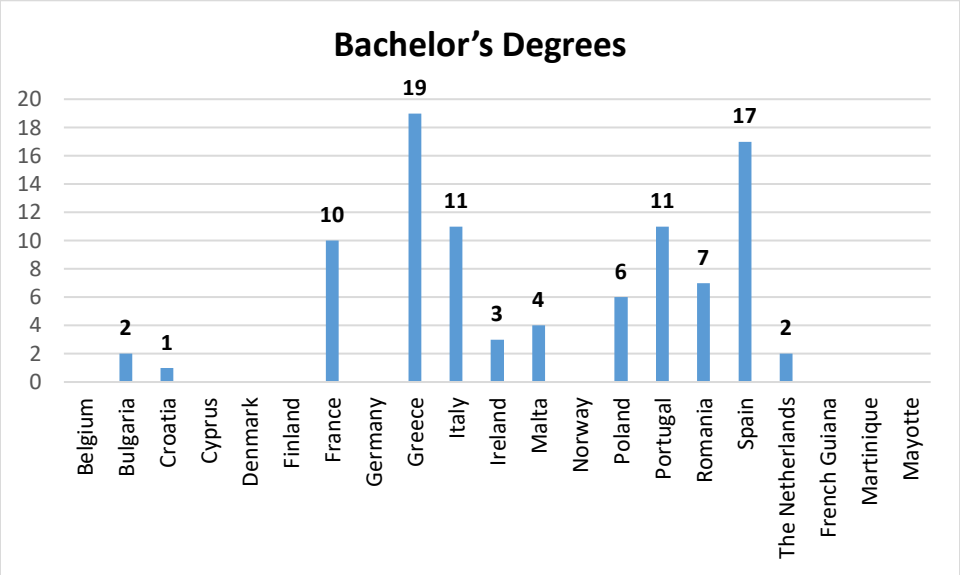
2.2 Undergraduate Studies in aquaculture (Bachelor's Degrees)

From the establishments recorded, the higher number is in Greece (19), followed by Spain (17) whereas Italy and Portugal follow with 11 in each of them. No establishments have been recorded in Belgium, Cyprus, Denmark, Finland, Germany, Norway, the Netherlands and all the French OR. It is clarified that these study programs are often not fully dedicated to aquaculture but include courses related to aquaculture.

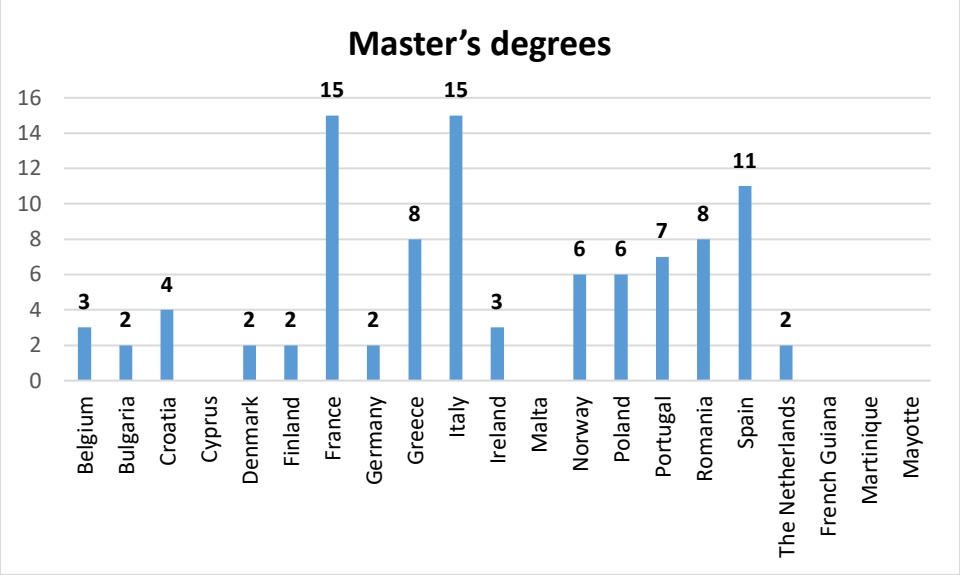
Figure 3. First cycle-Bachelor studies offering for Aquaculture in Europe and the French Outermost Regions of the Atlantic Ocean surveyed for the **BlueAquaEdu** Project.



2.3 Postgraduate Studies in aquaculture

It seems that most Countries have a preference for postgraduate studies in aquaculture, which is understandable as a kind of specialisation towards this activity. From the establishments recorded, the higher number is in Italy, and France (15 each) followed by Spain (11). Greece and Romania follow with 8 in each of them. No establishments have been recorded in Cyprus and all the French OR.

Figure 4. Second cycle- Master's degrees offering for Aquaculture in Europe and the French Outermost Regions of the Atlantic Ocean surveyed for the **BlueAquaEdu** Project.



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3 The offer per Country

A. BlueAquaEdu Countries

3.1 France

Aquaculture in France is a well-established sector with a lot of new opportunities. France has a strong aquatic food culture; this culture is a catalyst for the growth in the aquaculture field. Marine production is dominated by molluscs; mainly oyster, whereas the marine fish aquaculture sector has been developed through a research effort lasting 30 years, however, following early development successes, the marine fish aquaculture sector of seabass and seabream has been in competition with other countries. Currently, the main developmental potential of the French aquaculture sector is in the production of new marine species like red drum as well as high quality products like sturgeon caviar, selected strains for all fish species and quality labelled products[2].

In France, opportunities for higher education are related to employment, knowledge and research. The field is gaining significance due to the increasing demand for sustainable and safe seafood production. In France a lot of degrees can be delivered in Aquaculture. All the courses are delivered at different educational levels and institutions. Most of them are in public universities, legally recognized non-public universities, higher schools and institutions. Students will have study courses in biology, animal biology or veterinary sciences, ecology, freshwater or marine sciences and animal pathologies.

In France all the university courses are structured around the ECTS credit system.

Level 5 education courses

All these courses are high schools' education courses (60 ECTS when they are attached to a university). There are 15 different levels of Level 5 degrees in France. Eleven of them are in public schools and 4 in private schools. This type of diploma gives the students theoretical and practical knowledge estimated in 60% of educational knowledge and 40% of specific knowledge.

Students acquire knowledge of natural aquatic ecosystems, knowledge of species reared in aquaculture, aquaculture production based on exogenous feed, aquaculture production based on exploiting natural productivity, knowledge and use of aquaculture equipment, knowledge of sectors and markets.

Production environments, aquatic products, business economics, promotion and communication techniques are also studied. The types of production covered are salmon farming, shellfish farming, pond fish farming and new types of aquacultures (marine fish farming, sturgeon farming, algae culture) data processing and computer sciences. But also, technical applications at "Station Méditerranéenne de l'Environnement Littoral - SMEL[3]" (Mediterranean Station for Coastal Environment) for production of micro-algae, horticulture, aquaculture hatchery and Recirculating Aquaculture System (RAS), Integrated Multi-Trophic Aquaculture (IMTA), aquaponics and aquaculture. Laws of fisheries and aquaculture in France, how to manage health of the fish production bio-chemistry and water chemistry.

[2] https://www.fao.org/fishery/en/countrysector/fr/en?lang=en

[3]SMEL is a research institute located in France, specifically in the Occitanie region, near Montpellier. SMEL focuses on studying and monitoring the coastal environment of the Mediterranean Sea.

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The purpose of all these studies are to create a pool of new technicians or aquaculture technicians able to work in the aquaculture business.

These education programs typically take one or two years to complete and may include a combination of lectures, laboratory work, fieldwork and internships. Upon completion, students are awarded a degree (called DU or BTS in France) preparing them for careers in the aquaculture industry or further study in related fields of the respective discipline.

Bachelor's Degrees

In France, the completion of a bachelor's degree typically spans a duration of three years, equivalent to 120 ECTS credits. Prospective students may pursue a conventional bachelor's degree within a university setting or opt for a Level 5 qualification coupled with one year of university studies to attain a professional bachelor's degree. Notably, our examination has delineated 13 distinct bachelor's degree programs, with the preponderance of these being conferred by public universities, while only two are affiliated with private institutions.

The curriculum encompasses a comprehensive array of subjects including biology and ecology of organisms, encompassing topics such as physico-chemistry of water, ecology, pathology, welfare of captive animals and the design and execution of experiments. Further subjects include aquariology, covering aquariological sectors, techniques, animal biodiversity, and continental aquaculture. Advanced topics extend to the management of aquatic environments, breeding systems, advanced aquaculture, experimentation, data processing in environmental sciences, statistical analysis and digital spatial data processing.

In addition, students delve into specialized areas such as biology and ecology of microalgae, ecological habitat and bio-sourcing, microalgae characterization, techniques for strain isolation and purification, technical monitoring, and problem-solving. Proficiency in office software for result presentation, understanding farmers' needs for informed decision-making and engagement in collaborative project management are emphasized.

The curriculum further encompasses disciplines including biochemistry, cell biology, basic chemistry, solution chemistry, general aquaculture, ocean geology, chemical processes, physical and biological oceanography, separative techniques, molecular analyses, microbiology, molecular biology, marine plant and fauna biology, fisheries anatomy, ethology, geodesy, cartography, data processing, geographical information systems, maritime law, communication, office automation, quality, safety, and environmental management, risk assessment, and environmental regulations governing discharge and waste management.

The predominant focus of these courses revolves around continental and marine farming, thereby fostering specialization in either marine or freshwater biology. The overarching objective of these educational endeavours is to cultivate highly skilled technicians primed for employment within the aquaculture industry, proficient in conducting field tests on farms or in aquaculture laboratories.

Master's degrees

In France, the completion of a bachelor's degree spans a duration of five years, encompassing 300 ECTS credits. Students may pursue a traditional master's degree within a university context, requiring a bachelor's degree and specialization, or opt for a Level 5 qualification coupled with one year of university study to obtain a professional bachelor's degree alongside specialization in a master's program. Notably, our investigation has revealed 13 distinct master's degree programs, all of which are conferred by public universities.

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Across these master's degree programs, students undertake a comprehensive curriculum focusing on various aspects of the marine domain, encompassing resources and challenges, the structure and organization of marine ecosystems, ecological methodology, fisheries ecology, fundamentals of aquaculture and maritime law including international trade and fisheries regulations. Emphasis is placed on anticipating and addressing issues inherent in international trade, mastering relevant techniques and methodologies, understanding supply chain dynamics, optimizing logistical operations and developing expertise in financial, physical and informational flows associated with maritime activities. Proficiency in technical English for effective communication in professional settings is also cultivated.

Furthermore, coursework delves into marine chemistry, physical oceanography, marine ecophysiology, general oceanography, biodiversity of coastal ecosystems, environmental factors and adaptations, physiology and ecophysiology of marine organisms, ecology of anthropized aquatic ecosystems, biology of aquatic organism development and fisheries and aquaculture techniques. Additionally, students explore the valorisation of seafood products, socio-professional environments related to coastal areas, and the exploitation of fish and shellfish farming species.

Supplementary disciplines include nutrition and health, food microbiology, animal production quality, nutrition's role in food-health relations, food safety, and food innovation. Master's degrees in France are intricately linked to specialized fields such as science, ecology and biology, economy and fisheries, or nutrition and food research. Graduates of these programs emerge as adept coordination and management experts capable of conducting research, leading teams, or venturing into entrepreneurial endeavours within their respective domains.

Engineering degrees

In France an engineering degree takes 5 years to complete (300 ECTS). Our analysis has identified two distinct engineering degrees offered by specialized engineering schools.

These engineering programs prioritize the refinement and enhancement of aquaculture product transformation processes. Students engage in a curriculum centred on vital areas such as the safety and sanitation of aquatic products, microbiology, quality control measures and methods for increasing the value of food products. Alternatively, coursework may emphasize technical expertise pertaining to product characteristics and processing methodologies, often incorporating an Integrated Multi-Trophic Aquaculture (IMTA) approach.

3.2 Greece

Greece has developed a large aquaculture sector, representing a major share of national seafood production with finfish and mussels being the main groups of species produced. Fish farming (marine and fresh water) holds a dominant position of 84.8% in volume and 98.6% in value, followed by mussels with 15.1% and 1.2% respectively and microalgae (Spirulina, a high-value cyanobacterium of the genus Arthrospira) production with 0.1% in volume and 0.23% in value. The main species farmed are two finfish (European seabass and gilthead seabream) and shellfish (mussels)[4].

[4] https://www.fao.org/fishery/en/countrysector/gr/en?lang=en

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In freshwater aquaculture in Greece, the main species reared are the Rainbow trout (*Oncorhynchus mykiss*), Common carp (*Cyprinus carpio*), Coho salmon (*Oncorhynchus cisutch*), European eel (*Anguila anguila*) and spirulina species[5].

Aquaculture is one of the key productive sectors where Greece possesses competitive advantages and dynamic potential for economic growth in the framework of smart specialisation strategies. Among them, favourable environmental and climatic conditions, the availability of adequate sea and inland areas, the longstanding experience and scientific know-how, the existing infrastructure and skilled human resources. In addition, aquaculture products head Greece's export goods, confirming the extroversion of the sector, its contribution to the real economy and its outlook for further development.

In Greece, avenues for higher education in aquaculture intersect with employment prospects, knowledge dissemination and research endeavours. The field is gaining prominence owing to the escalating demand for sustainable and safe seafood production. Greece offers a plethora of academic programs catering to aquaculture across various educational levels and institutions. These encompass public universities, legally recognized private institutions, higher schools, and specialized institutions.

Students enrolled in these programs undergo comprehensive coursework covering disciplines such as biology, animal biology, veterinary sciences, ecology, freshwater or marine sciences, and animal pathologies. The academic structure in Greece adheres to the European Credit Transfer and Accumulation System (ECTS), ensuring standardized credit allocation across university courses.

First cycle-Bachelor studies

In Greece, first-cycle bachelor studies, known as "πρώτος κύκλος σπουδών" or "βασικό πρόγραμμα σπουδών," typically last for four years. These programs are offered by universities and higher education institutions throughout the country and cover a wide range of disciplines, including natural sciences, social sciences, humanities, engineering, and more.

For aquaculture-specific bachelor programs in Greece, students may pursue degrees in fields such as marine biology, aquaculture science, fisheries science, environmental science, or agricultural science with a specialization in aquaculture. These programs provide students with a comprehensive understanding of aquaculture principles, including fish biology, aquaculture systems and technologies, water quality management, environmental sustainability, and aquaculture economics.

During the bachelor's program, students participate in a variety of learning activities, including lectures, laboratory work, field trips, and potentially internships or research projects. The curriculum is designed to provide students with a strong theoretical foundation and practical skills relevant to the aquaculture industry.

Upon successful completion of the first-cycle bachelor studies in aquaculture or related fields, students are awarded a bachelor's degree (πτυχίο) in the respective discipline. This qualification prepares graduates for various career paths within the aquaculture sector, including fish farming, aquaculture management, research, environmental consulting, and governmental or non-governmental organizations involved in aquatic resource management.

[5] https://aquaculture.ec.europa.eu/country-information/greece

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Overall, first-cycle bachelor studies in aquaculture in Greece offer students a comprehensive education and prepare them to contribute effectively to the sustainable development and management of aquatic resources within the country and beyond.

Second cycle - Master's degree

In Greece, second-cycle Master's degree programs, commonly known as "μεταπτυχιακό πρόγραμμα σπουδών," typically span one to two years of full-time study. These programs are offered by universities and higher education institutions across the country and cover various fields, including natural sciences, social sciences, humanities, engineering, and more.

For aquaculture-specific Master's degree programs in Greece, students may pursue degrees in disciplines such as Marine Biology, Aquaculture Science, Fisheries Science, Environmental Science, or Agricultural Science with a specialization in Aquaculture. These programs provide students with advanced knowledge and specialized skills in various aspects of aquaculture, including fish physiology, aquaculture systems and technologies, aquaculture management, environmental impact assessment, and aquaculture policy and regulation.

Throughout the Master's program, students engage in a combination of classroom lectures, laboratory work, fieldwork, seminars, and potentially internships or research projects. The curriculum is designed to deepen students' understanding of complex aquaculture concepts and methodologies and equip them with the analytical and critical thinking skills necessary for advanced research or professional practice in the field.

Upon successful completion of the second-cycle Master's degree in aquaculture or related fields, students are awarded a Master's degree (Μεταπτυχιακό Δίπλωμα) in the respective discipline. This qualification enhances graduates' prospects for career advancement in various sectors of the aquaculture industry, including aquaculture production, aquaculture research and development, environmental consulting, policy-making, academia, and international organizations involved in fisheries and aquaculture management.

In summary, second-cycle Master's degree programs in aquaculture in Greece provide students with advanced knowledge and skills to address the complex challenges facing the aquaculture sector and contribute to its sustainable development and management.

Vocational training

In Greece, vocational training for aquaculture is offered through various institutions, including vocational schools, technical colleges and specialized training centres. These programs provide practical, hands-on training to individuals interested in pursuing careers in the aquaculture industry.

Vocational training for aquaculture in Greece covers a wide range of topics relevant to the sector, including fish farming techniques, hatchery operations, aquaculture systems and equipment, water quality management, feed formulation, disease prevention and control, and environmental sustainability practices.

These training programs often include a combination of classroom instruction, laboratory work, and on-the-job training or internships at aquaculture facilities. Students learn from experienced aquaculturists and industry professionals who provide valuable insights and practical skills necessary for success in the field.

Upon completion of vocational training programs in aquaculture, graduates are equipped with the knowledge and skills needed to pursue entry-level positions in various sectors of the aquaculture industry, including fish farms, hatcheries, feed mills, aquaculture equipment suppliers and environmental consulting firms.

In addition to formal vocational training programs, there may also be opportunities for informal apprenticeships or on-the-job training within the aquaculture industry. These hands-on learning experiences provide valuable practical skills and industry connections for individuals seeking to enter the workforce directly.

3.3 Portugal

Aquaculture in Portugal stands as a well-established sector ripe with emerging opportunities. The country's rich aquatic gastronomic heritage serves as a driving force for the advancement of the aquaculture industry. Portugal has the third highest per capita fish consumption in Europe, where the main fish consumed in Portugal are small pelagic fish, especially sardine and horse mackerel deriving from fisheries activities. Aquaculture production in 2015, primarily consisted of marine bivalves and marine fin fish grown mostly from mariculture and land-based aquaculture farms[6].

In Portugal, higher education opportunities in aquaculture intersect with employment prospects, knowledge acquisition, and research pursuits. The sector is gaining prominence in response to the growing demand for sustainable and secure seafood production. Portugal offers a diverse range of academic programs specializing in aquaculture across various educational levels and institutions. These encompass public universities, legally recognized private institutions, higher education establishments, and specialized research institutions.

Students enrolled in these programs undergo comprehensive coursework covering a wide array of disciplines, including biology, animal biology, veterinary sciences, ecology, freshwater or marine sciences, and animal pathologies. The academic framework in Portugal follows the European Credit Transfer and Accumulation System (ECTS), ensuring standardized credit allocation across university courses.

First cycle-Bachelor studies

In Portugal, first-cycle Bachelor studies in aquaculture are typically part of broader programs in marine sciences, fisheries, or agricultural sciences. These programs provide students with a comprehensive understanding of aquaculture principles, practices, and techniques, as well as broader knowledge in related fields such as biology, ecology, and environmental science.

Bachelor programs in aquaculture in Portugal typically span three to four years of full-time study and are offered by universities, technical institutes, and specialized agricultural schools across the country. Students may enroll in programs such as "Licenciatura em Ciências do Mar" (Bachelor of Marine Sciences) or "Licenciatura em Ciências Agronómicas" (Bachelor of Agricultural Sciences) with a specialization in aquaculture.

The curriculum of these programs covers a wide range of topics relevant to aquaculture, including fish biology, aquatic ecology, aquaculture systems and technologies, water quality management, nutrition and feed formulation, disease prevention and control, environmental sustainability, and aquaculture business management.

Throughout the Bachelor studies, students engage in a combination of theoretical coursework, laboratory practical's, fieldwork, and potentially internships or research projects. This hands-on approach allows students to develop both theoretical knowledge and practical skills necessary for a career in aquaculture.

[6] https://www.fao.org/fishery/en/facp/prt

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Upon successful completion of the Bachelor studies in aquaculture or related fields, students are awarded a Bachelor's degree (Licenciatura) in the respective discipline. This qualification prepares graduates for various entry-level positions in the aquaculture industry, including fish farming, hatchery operations, aquaculture research, environmental consulting, and governmental or non-governmental organizations involved in aquatic resource management.

Second cycle- Master's degree

In Portugal, postgraduate studies in aquaculture are available at both master's and doctoral levels, offering advanced education and research opportunities for individuals seeking to deepen their knowledge and expertise in this field.

Master's Degree (Mestrado):

Master's degree programs in aquaculture typically span one to two years and are offered by universities and research institutions across Portugal. These programs provide students with advanced training in various aspects of aquaculture, including sustainable production techniques, resource management, environmental impact assessment, and aquaculture policy and regulation.

The curriculum of master's programs in aquaculture may include a combination of coursework, laboratory work, fieldwork, seminars, and potentially internships or research projects. Students have the opportunity to explore specialized topics and develop practical skills relevant to their interests and career goals.

Upon successful completion of a master's degree program in aquaculture, graduates are awarded a Master's degree (Mestrado) in the respective discipline. This qualification prepares graduates for leadership roles in the aquaculture industry, research institutions, government agencies, non-governmental organizations, and international organizations involved in fisheries and aquaculture management.

Vocational training

In Portugal, vocational training for aquaculture is available through various institutions, including vocational schools, technical institutes, and specialized aquaculture training centres. These programs are designed to provide practical, hands-on training to individuals interested in pursuing careers in the aquaculture industry.

Vocational training for aquaculture in Portugal covers a wide range of topics relevant to the sector, including fish farming techniques, hatchery operations, aquaculture systems and equipment, water quality management, feed formulation, disease prevention and control and environmental sustainability practices.

These training programs typically consist of a combination of classroom instruction, laboratory work, and practical training at aquaculture facilities. Students learn from experienced aquaculturists and industry professionals who provide valuable insights and mentorship to help develop the necessary skills for success in the field.

Upon completion of vocational training programs in aquaculture, graduates are equipped with the knowledge and skills needed to pursue entry-level positions in various sectors of the aquaculture industry, including fish farms, hatcheries, feed mills, aquaculture equipment suppliers and environmental consulting firms.

In addition to formal vocational training programs, there may also be opportunities for apprenticeships or on-the-job training within the aquaculture industry in Portugal. These hands-on learning experiences provide valuable practical skills and industry connections for individuals seeking to enter the workforce directly.

B. Other European Countries

3.4 Belgium

Aquaculture production in Belgium is rather small, and even declining in recent years. At present some 86 tonnes are produced. Only freshwater aquaculture production exists in Belgium, mainly consisting in trout farming[7] at small-scale in Wallonia region.

Aquaculture education in Belgium spans various levels, from foundational bachelor's programs to advanced master's degrees and practical vocational training. This comprehensive educational framework supports the development of skilled professionals capable of advancing the industry despite its current small scale. By fostering expertise and sustainable practices, Belgium's educational institutions contribute to the potential growth and innovation in the aquaculture sector.

First cycle-Bachelor studies

In Belgium, the first cycle of aquaculture education typically involves bachelor's degree programs that provide a solid foundation in aquatic sciences, biology and environmental management. These programs are designed to equip students with the fundamental knowledge and skills necessary for understanding the principles of aquaculture and its applications. Key components of the curriculum include courses in fish biology, water quality management, aquaculture systems design, and sustainable practices. Students also gain hands-on experience through laboratory work and field trips to local aquaculture facilities, particularly the small-scale trout farms prevalent in the Wallonia region. Institutions offering these programs may include universities and specialized colleges that emphasize environmental and biological sciences.

Second cycle- Master's degree

For those seeking advanced education in aquaculture, Belgium offers second cycle programs leading to a Master's degree. These programs delve deeper into the scientific, technological and managerial aspects of aquaculture. Coursework often covers advanced topics such as fish nutrition, disease management, genetic improvement and innovative aquaculture technologies. Students engage in research projects, often collaborating with industry partners or participating in internships to gain real-world experience. Master's programs aim to develop expertise that can contribute to solving complex challenges in the aquaculture industry and to promote sustainable practices. Graduates are prepared for roles in research, industry leadership, policy development and education.

Vocational training

Vocational training in aquaculture in Belgium provides practical and job-oriented education for individuals aiming to enter the aquaculture workforce directly. These programs focus on developing specific skills needed for day-to-day operations in aquaculture facilities. Training typically includes hands-on instruction in fish husbandry,

[7] https://www.fao.org/fishery/en/facp/BEL

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water quality monitoring, equipment maintenance and farm management. Vocational courses are designed to be responsive to industry needs, often involving collaborations with local aquaculture businesses to ensure that the training is relevant and up-to-date. These programs are ideal for those looking to quickly gain the skills necessary for employment in Belgium's freshwater aquaculture sector, especially in small-scale trout farming.

3.5 Bulgaria

In Bulgaria, although the rearing of different aquatic species dates back many years, aquaculture has emerged as a new activity in Bulgaria, therefore the sector cannot be considered to be the one to determine the structure of the country's economy, but it occupies a specific and important position in the economic existence and way of life of the Bulgarian people[8]. Aquaculture can be divided into two main sub-sectors: freshwater aquaculture (warm water and coldwater) and marine aquaculture. The most popular fish reared are rainbow trout (*Oncorhynchus mykiss*), common carp (*Cyprinus carpio*) and Chinese carps (*Hypophthalmichthys molitrix, Hypophthalmichthys nobilis, Ctenopharyngodon idellus*) whereas the main output from marine aquaculture is the Mediterranean mussel (*Mytilus galloprovincialis*)[8].

Aquaculture education in Bulgaria is structured to support the development of skilled professionals across various levels, from bachelor's and master's degree programs to practical vocational training. This educational framework aims to enhance the capacity of the aquaculture sector, which, while not a dominant part of the national economy, holds significant importance for the local communities and overall economic landscape. By fostering a knowledgeable and skilled workforce, Bulgaria's educational institutions contribute to the sustainable growth and innovation within the aquaculture industry.

First cycle-Bachelor studies

In Bulgaria, the first cycle of aquaculture education typically involves bachelor's degree programs designed to provide students with a foundational understanding of aquaculture practices and principles. These programs are offered by universities and specialized agricultural institutions, focusing on courses such as fish biology, aquatic ecology, water quality management and sustainable aquaculture practices. Students are also introduced to the economics of aquaculture and the regulatory framework governing the industry. Practical experience is an integral part of these programs, with hands-on training in freshwater and marine aquaculture environments. Popular institutions for bachelor studies in aquaculture include the Agricultural University in Plovdiv and Trakia University in Stara Zagora.

Second cycle- Master's degree

For advanced education, Bulgaria offers master's degree programs that delve deeper into the scientific and technical aspects of aquaculture. These second cycle programs are aimed at developing expertise in specialized areas such as fish nutrition, disease management, genetic breeding and aquaculture engineering. The curriculum is designed to include advanced coursework, research projects, and internships that provide practical industry experience. Students often have the opportunity to collaborate with research institutions and industry stakeholders, which helps them address real-world challenges in the aquaculture sector. Institutions like Sofia University and the Institute of Fisheries Resources in Varna are known for their comprehensive master's programs in aquaculture.

[8] https://www.fao.org/fishery/en/countrysector/bg/en?lang=en

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Vocational training

Vocational training in aquaculture in Bulgaria provides practical, hands-on education for individuals seeking to enter the workforce quickly and effectively. These programs are offered by technical schools, agricultural colleges and training centres across the country. Vocational courses focus on essential skills such as fish farming techniques, hatchery management, water quality monitoring and equipment maintenance. The training is tailored to meet the needs of both freshwater and marine aquaculture, covering species like rainbow trout, common carp, Chinese carps and bivalve molluscs (mussels). By collaborating with local aquaculture farms and businesses, these vocational programs ensure that the training remains relevant and up-to-date with industry practices.

3.6 Croatia

Aquaculture in Croatia is a growing sector. Croatia is known for a strong aquaculture industry especially on marine species the European seabass (*Dicentrarchus labrax*), gilthead seabream (*Sparus aurata*) and Atlantic bluefin tuna (*Thunnus thynnus*). Shellfish farming comprises farming of Mediterranean mussel (*Mytilus galloprovincialis*) and European flat oyster (*Ostrea edulis*). In addition, freshwater aquaculture includes production of warm-water (cyprinid or carp-like) species and cold-water (salmonid or trout-like) species, dominantly common carp (*Cyprinus carpio*) and rainbow trout (*Oncorhynchus mykiss*)[9].

In Croatia, opportunities for higher education are related to employment, knowledge and Research. The field is gaining significance due to the increasing demand for sustainable and safe seafood production. Croatia can deliver a degree in Aquaculture. All the courses are delivered in different educational level and institutions. Students will have study courses in Biology, animal biology or veterinary science, ecology, freshwater or marine science and animal pathology and economical management.

In Croatia they use the ECTS system.

First cycle-Bachelor studies

In Croatia, a bachelor's degree program typically requires the completion of 180 ECTS credits. In Croatia, the University of Dubrovnik administers a professional degree program in Aquaculture at the first cycle bachelor level, comprising 180 ECTS credits.

The Aquaculture program at the University of Dubrovnik is designed to furnish students with an extensive comprehension and proficiency in diverse facets of aquatic biology and ecology. Principal subjects encompassed within the curriculum entail:

- Comprehensive exploration of the biology and ecology of organisms, with emphasis on the physico-chemical attributes of water, ecological dynamics, animal pathology, and the welfare of captive organisms.
- Rigorous instruction in experimental design and management, encompassing linguistic competencies, experimental methodologies, and biometric techniques.
- Thorough examination of aquariology and aquaculture methodologies, inclusive of themes such as animal biodiversity and continental aquaculture methodologies.

[9] https://www.fao.org/fishery/en/countrysector/hr/en?lang=en

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- In-depth study of continental aquaculture practices, with a focal point on the strategic management of aquatic environments, breeding systems, and the propagation of sustainable aquaculture methodologies.

The purpose of the courses is to make high profile of technicians able to work in aquacultures business and make field testing on the farm. And this is an introduction for a Master degree in fisheries.

The overarching objective of the Aquaculture degree program is to cultivate highly adept technicians capable of making substantial contributions to the aquaculture domain. The anticipated outcomes of the program are as follows:

- To nurture students' comprehension of foundational principles and practices underpinning aquaculture.
- To impart practical proficiencies enabling students to conduct field tests and experiments within aquaculture settings.
- To furnish a robust groundwork for further academic pursuits and specialization, particularly within the domain of fisheries, at the master's level.

Second cycle- Master's degree

In Croatia, a bachelor's degree program typically requires the completion of 180 ECTS credits. Graduation necessitates the fulfilment of both a bachelor's program and a subsequent specialization pursued within a master's degree program. Our investigation has identified four distinct master's degree programs, all offered by public universities.

The curriculum of these master's degree programs encompasses a broad spectrum of topics aimed at fostering expertise in marine and aquaculture disciplines. Students enrolled in these programs will delve into areas such as:

- Mariculture technology
- Sustainable fish farming practices
- Sustainable bivalve mollusk farming
- Diseases affecting cultivated organisms
- Fish nutrition and live feed culture
- Physiology of cultured organisms
- Aquaculture waste management
- Mariculture genetics
- Diversification strategies in mariculture
- Aquaculture food safety measures
- Fisheries management, including freshwater ichthyology and fisheries
- Environmental aspects of fishing
- Oceanology and limnology
- Physiology of aquatic organisms
- Protection and management of water systems
- Ecology of aquatic ecosystems
- Integrated coastal belt management
- Technology for the cultivation of aquatic organisms

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- Management of aquaculture and fisheries
- Management of marine protected areas

Master's degree programs in Croatia are focused on the scientific disciplines of ecology and biology. Graduates emerge as marine and aquaculture experts equipped with the necessary skills to conduct research both on farms and in private laboratories. These programs aim to cultivate professionals capable of addressing the complex challenges and opportunities inherent in the marine and aquaculture industries.

Vocational training

In Croatia, vocational training for aquaculture is provided by several institutions, including technical schools, agricultural colleges and specialized training centres. These institutions focus on practical, job-oriented education to equip individuals with the skills needed for immediate employment in the aquaculture sector. Some of the key providers of vocational training in aquaculture in Croatia include:

Vocational Schools and Technical Institutes

Various vocational schools and technical institutes across Croatia offer specialized courses in aquaculture. These programs cover essential skills such as fish farming techniques, hatchery management, and equipment maintenance. Examples include the following Institutions:

- Maritime and Technical School Dubrovnik (Pomorska i tehnička škola Dubrovnik): Offers courses related to marine biology and aquaculture.
- Agricultural School Zagreb (Poljoprivredna škola Zagreb): Provides training in aquaculture practices and water quality management.

University of Dubrovnik

While primarily a higher education institution, the University of Dubrovnik also offers practical training and certification courses aimed at individuals seeking vocational education in marine aquaculture. These programs often include hands-on training and collaboration with local aquaculture businesses.

Institute of Oceanography and Fisheries in Split

This research institution provides training workshops and certification courses for those interested in aquaculture. Their programs are designed to offer practical skills and knowledge, leveraging their extensive research and industry connections.

Private Training Centres and Organizations

Several private organizations and training centres offer specialized vocational courses in aquaculture. These programs are tailored to meet the needs of the aquaculture industry, providing up-to-date training on the latest practices and technologies.

These institutions ensure that students receive comprehensive vocational education that includes both theoretical knowledge and practical skills, preparing them for successful careers in Croatia’s aquaculture industry.

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3.7 Cyprus

The main type of aquaculture carried out in Cyprus is marine aquaculture (Mariculture) and is currently carried out exclusively on the southern coasts of the country and the culture method utilized is open sea cage culture. The production of marine fish has been showing an increasing trend over the last few years. The main marine species commercially cultured were the gilthead seabream (*Sparus aurata*) and European seabass *(Dicentrachus labrax*)[10]. The following species are also produced in much smaller quantities (1%): meagre (*Argyrosomus regius*) and the Indian white prawn (*Penaeus indicus*). Freshwater fish production is also carried out to some extent.

In Cyprus, no establishments for aquaculture education have been identified. The newly established Cyprus Marine and Maritime Institute (CMMI) which is a "Centre of Excellence in Marine and Maritime Research, Technology Development and Innovation" is comprised of various Centres, among which the Marine Biotechnology and Aquaculture Centre – MBAC, explores the most recent advances in the diverse fields of "Blue" Biotechnology and Aquaculture. The MBAC takes full advantage of the unique geographic location of Cyprus in the eastern part of the Mediterranean Sea, an area characterised by a large number of endemic marine and coastal biota with promising and untapped biotechnological value. In addition, the Centre conducts applied research in the broader field of the aquaculture industry with emphasis on reproductive biology in captivity conditions, enhancement of production through sustainable practices, Integrated Multitrophic Aquaculture – IMTA, as well as multidisciplinary methodologies that evaluate the bioremediation ability of certain marine species. To this end, MBAC collaborates closely with prestigious academic and research institutions as well as Industry leaders to tackle the most critical challenges in the fields of marine biotechnology and aquaculture.

More specifically, the centre's research interests are the following:

- Reproductive physiology
- Innovative feeding methods
- Integrated Multitrophic Aquaculture
- Bioremediation in the marine environment
- Production biofuels
- Pharmaceuticals

Contact information: MBAC@cmmi.blue

3.8 Denmark

Denmark holds a prominent position in fish production, with a long-standing and well-established tradition in aquaculture. The primary product is rainbow trout from freshwater ponds and mariculture units, the latter also producing roe as an important by-product. Fish juveniles are also produced in specialised hatcheries and sold for further on-growing in freshwater ponds and mariculture units, or for restocking purposes. Denmark does not have salmon farms, except for small quantities produced for restocking. Eel is farmed using recirculated freshwater tank systems. Danish eel farming technology is of a high standard and there is a considerable level of export of this technology and know-how.

Additionally, mussels and oysters are produced in minor quantities and are usually cultivated on vertical ropes or in socks hanging from suspended lines ('longline' systems) tied to floating buoys which are anchored to the

[10] https://www.fao.org/fishery/en/countrysector/cy/en

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bottom. Farmed mussels grow quicker than wild mussels and have a higher 'meat percentage', as a result of this, they are used primarily for direct consumption and are sold at higher prices than wild caught mussels. Turbot fry is exported for further on-growing. A variety of other species are raised primarily for restocking which represents an increasing share of total turnover[11].

Aquaculture education in Denmark is well-structured and comprehensive, spanning from foundational bachelor's programs to advanced master's degrees and practical vocational training. This educational framework supports the development of skilled professionals capable of driving innovation and sustainability in Denmark's prominent aquaculture sector. By offering a blend of theoretical knowledge and practical experience, Danish educational institutions contribute significantly to the growth and international competitiveness of the country's aquaculture industry.

First cycle-Bachelor studies

In Denmark, the first cycle of aquaculture education is offered through bachelor's degree programs at universities and specialized institutions. These programs provide a strong foundation in aquatic sciences, biology, and environmental management, preparing students for various roles within the aquaculture industry. Core courses include fish biology, aquaculture systems and technology, water quality management and sustainable practices in aquaculture. Students gain practical experience through laboratory work, field trips, and internships at fish farms and hatcheries, including those specializing in rainbow trout and eel farming. A notable institution offering bachelor's degrees in aquaculture is the Technical University of Denmark (DTU) which has strong programs in environmental and life sciences.

Second cycle- Master's degree

For advanced education, Denmark offers master's degree programs that delve deeper into the scientific, technical and managerial aspects of aquaculture. These second cycle programs cover advanced topics such as fish nutrition and health, genetic improvement, recirculating aquaculture systems (RAS), and aquaculture economics. Students engage in research projects, often collaborating with industry partners, to address real-world challenges and innovate within the sector. Master's programs are designed to develop expertise that can lead to leadership roles in research, industry, or policy-making. Institutions such as the University of Copenhagen and DTU offer comprehensive master's programs in aquaculture and related fields, leveraging Denmark's strong tradition and technological expertise in the industry.

Vocational training

Vocational training in aquaculture in Denmark is aimed at providing practical, hands-on education for individuals seeking to enter the aquaculture workforce directly. These programs are offered by technical schools, agricultural colleges, and specialized training centres. Vocational courses focus on essential skills such as fish farming techniques, hatchery management, water quality monitoring, and equipment maintenance. Training often includes practical experience with systems like recirculated freshwater tanks for eel farming and mariculture units for rainbow trout and mussels. Denmark's vocational training is known for its high standards, particularly in eel farming technology, which is exported globally. Collaboration with local aquaculture businesses ensures that the training is up-to-date and industry-relevant.

[11] https://www.fao.org/fishery/en/countrysector/dk/en?lang=en

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In Denmark, vocational training for aquaculture is provided by several institutions that focus on delivering practical, hands-on education tailored to the needs of the aquaculture industry. Key providers of vocational train

Technical Education Copenhagen (TEC)

TEC provides a variety of technical and vocational training programs, including those related to aquaculture. Their programs emphasize practical training and industry collaboration, ensuring that graduates are well-equipped for careers in aquaculture.

Viking Fish School (VikingeFiskerskolen)

Located in West Jutland, this school offers specialized training in fish farming techniques, focusing on practical skills and hands-on experience. They collaborate closely with local aquaculture businesses, providing students with relevant industry insights and opportunities.

Green Academy Aarhus (Grønne Akademi Aarhus):

Green Academy offers vocational programs in agriculture and aquaculture, focusing on sustainable practices and modern aquaculture technologies. Their training includes practical experience in fish farming, water quality management and hatchery operations.

These institutions ensure that students receive comprehensive vocational training that includes both theoretical knowledge and practical experience, preparing them for successful careers in Denmark's aquaculture sector. The collaboration with local businesses and industry experts helps ensure that the training is up-to-date and relevant to the current needs of the aquaculture industry.

3.9 Finland

Aquaculture in Finland has solidified its position as a thriving sector, teeming with promising opportunities. The nation boasts a robust aquaculture industry, particularly renowned for its production of rainbow trout *(Oncorhynchus mykiss*), amounting to over 13,000 tonnes annually and European whitefish (*Coregonus lavaretus*). This flourishing industry serves as a pivotal catalyst for the expansion of the aquaculture field in Finland. In 2021, 79% of Finnish production occurred in brackish water almost entirely in cages and 21% in freshwater mainly in tanks and raceways[12].

Higher education opportunities in Finland are intricately linked to employment prospects, knowledge acquisition, and research endeavors within the aquaculture sector. The field is experiencing a surge in importance owing to escalating demands for sustainable and safe seafood production practices. Finland offers a range of educational programs in aquaculture, dispersed across various educational levels and institutions.

Students enrolled in these programs undergo comprehensive coursework encompassing biology, animal biology, veterinary science, ecology, freshwater or marine science, animal pathology, and principles of economical management. The curriculum is designed to equip students with a holistic understanding of aquaculture practices, ensuring they are well-prepared to address the multifaceted challenges and opportunities within the industry.

[12] https://aquaculture.ec.europa.eu/country-information/finland

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In Finland, the ECVET competence point system is utilized, serving as an equivalent to the European Credit Transfer and Accumulation System (ECTS). This standardized system facilitates the recognition and transfer of competencies and qualifications acquired by individuals engaged in aquaculture education and training programs.

First cycle-Bachelor studies

In Finland, one fundamental degree program has been identified, specifically the Basic Degree in Fisheries offered by Salpaus Further Education. This diploma equips students with both theoretical understanding and practical skills essential for the aquaculture industry. The program spans 180 ECVET credits.

Students enrolled in this program acquire comprehensive knowledge covering various aspects of aquaculture. This includes understanding natural aquatic ecosystems, species reared in aquaculture and different production methods such as those reliant on external feed or exploiting natural productivity. Additionally, students gain proficiency in the utilization of aquaculture equipment, knowledge of market sectors, and business economics.

Key areas of study encompass production environments, aquatic products, marketing techniques, and communication strategies. Specific focus is given to salmon farming, as well as understanding Finnish fisheries and aquaculture laws, managing fish health and principles of biochemistry and water chemistry. Traditional subjects such as mathematics and history are also included in the curriculum.

The overarching objective of these studies is to cultivate a skilled workforce for the aquaculture industry. Graduates emerge equipped with the expertise to feed fish, produce fry and ensure the well-being of aquatic organisms, thus contributing effectively to the aquaculture sector's workforce.

Professional Degree

In Finland, Livia College offers a professional degree program comprising 150 ECVET credits, leading to certification as a professional in fish farming. This qualification is essential for individuals seeking employment within the fish farming industry in Finland.

Students enrolled in this program undergo comprehensive training covering various aspects of aquaculture. This includes in-depth study of the biology and ecology of organisms, encompassing topics such as water physico-chemistry, ecology, pathology, and animal welfare. Additionally, students acquire practical skills in designing and conducting experiments, utilizing language proficiency, experimental methodologies, and biometric techniques. The curriculum also includes instruction in aquariology, animal biodiversity, continental aquaculture management, breeding systems and practical techniques for fish farming activities.

Specialized topics such as the biology and ecology of microalgae, ecological habitat assessment, and techniques for characterizing and purifying microalgae strains are also covered. Furthermore, students gain knowledge in discharge and waste management practices relevant to aquaculture operations.

Practical training forms a significant component of the program, equipping students with hands-on experience in fish farming activities. This includes aspects such as feeding fish, producing fry, and ensuring the well-being of aquatic organisms. Students also receive training in maintaining aquaculture facilities, including both conventional aquaculture systems and Recirculating Aquaculture Systems (RAS).

The primary objective of the program is to cultivate highly skilled technicians capable of contributing effectively to the aquaculture industry. Graduates emerge equipped with the practical knowledge and technical expertise required to work in various roles within aquaculture businesses, as well as conduct field testing on fish farms.

Master's Degrees

In Finland, a bachelor's degree program typically requires the completion of 120 ECVET credits. Pursuing a classical master's degree at a university entails first obtaining a bachelor's degree and then specializing further in a master's program. Our investigation has identified two distinct master's degree programs, all offered by public universities.

The curriculum of these master's degree programs is designed to provide students with comprehensive knowledge and skills in marine and aquaculture sciences. Students enrolled in these programs will delve into a wide range of topics, including:

- The marine environment, its resources, and associated challenges.
- The structure and organization of marine ecosystems, ecological methodologies, and fisheries ecology.
- Fundamentals of aquaculture, including relevant legal frameworks such as the law of the sea and fisheries law.
- Marine chemistry, physical oceanography, and marine ecophysiology.
- Biodiversity and environmental factors affecting coastal ecosystems.
- Physiology and ecology of anthropized aquatic ecosystems.
- Nutrition, food microbiology, animal production quality, and food-health relations.
- Food safety and innovation in food production.

Master's degrees in Finland focus on scientific principles, ecology, and biology. Graduates of these programs emerge as marine and aquaculture experts, equipped with the necessary skills to conduct research in various settings, including farms and private laboratories. These programs are designed to prepare students for careers in academia, industry, government agencies, and non-profit organizations within the marine and aquaculture sectors.

3.10 Germany

Aquaculture in Germany is a small industry in which the design and construction of production units as well the production densities vary widely with earthen ponds with a low stocking density being dominant. At the same time, some companies are operating modern farms equipped with tanks or raceways and high production densities. Traditional aquaculture species in Germany include common carp and rainbow trout which are farmed in earthen ponds, raceways and others modern indoor and outdoor facilities whereas aquaculture in brackish and marine waters mainly focus on blue mussel (*Mytilus edulis*)[13].

The farming of carp in freshwater ponds is the second major type of aquaculture practiced in Germany and has a long tradition.

Aquaculture education in Germany spans a range of programs, from foundational bachelor's degrees to advanced Master's degrees and practical vocational training. This comprehensive educational framework

[13] https://www.fao.org/fishery/en/countrysector/de/en?lang=en

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supports the development of skilled professionals capable of advancing the aquaculture industry. By offering a blend of theoretical knowledge and practical experience, German educational institutions contribute significantly to the growth and innovation of the aquaculture sector, which plays an important role in the country's economy and environmental sustainability efforts.

First cycle-Bachelor studies

In Germany, the first cycle of aquaculture education is offered through bachelor's degree programs at Universities and specialized Institutions. These programs aim to provide a solid foundation in aquaculture, marine biology and environmental sciences. Core subjects typically include fish biology, aquaculture systems and technology, water quality management and sustainable aquaculture practices. Additionally, students learn about the economic and regulatory aspects of the aquaculture industry. Practical experience is emphasized, with students engaging in laboratory work, field trips and internships at aquaculture facilities. Notable institutions offering bachelor's programs in aquaculture include the University of Rostock, which has a strong focus on marine sciences and the University of Kiel, known for its research in fisheries and aquaculture.

Second cycle- Master's degree

For those seeking advanced education in aquaculture, Germany offers master's degree programs that delve deeper into the scientific, technological and managerial aspects of the field. These second cycle programs cover advanced topics such as fish nutrition, disease management, genetic improvement, recirculating aquaculture systems (RAS) and aquaculture economics. The curriculum includes both theoretical coursework and practical training, with students often participating in research projects and collaborating with industry partners. Master's programs are designed to develop expertise that prepares graduates for leadership roles in research, industry, or policy-making. Institutions such as the University of Bremen and the University of Hamburg are known for their comprehensive master's programs in aquaculture and related disciplines.

Vocational training

Vocational training in aquaculture in Germany provides practical, hands-on education for individuals looking to enter the workforce directly. These programs are offered by vocational schools, technical colleges and specialized training centres. Vocational courses focus on essential skills such as fish farming techniques, hatchery management, water quality monitoring, and equipment maintenance. Training programs are closely aligned with industry needs and often involve apprenticeships or practical placements at aquaculture businesses. Notable providers of vocational training in aquaculture include:

Berufsschule Traunstein

Offers specialized vocational courses in aquaculture, emphasizing practical skills and industry collaboration.

DEULA (German Agricultural Training Centres)

DEULA centres across Germany offer practical training programs in aquaculture and fisheries management.

Landesfischereischule (State Fisheries Schools)

Located in various states, these schools provide vocational training focused on fish farming, hatchery operations and sustainable aquaculture practices.

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3.11 Italy

Aquaculture in Italy is a growing sector with the field gaining significance due to the increasing demand for sustainable and safe seafood production. Since 1980s, Italy played a major role in the development of modern aquaculture in the Mediterranean region while the production of fish and shellfish increased from the 1980s to the early 2000s. Although forty species of fish, shellfish and crustaceans are farmed, 97 percent of the production is based on five species: rainbow trout in freshwater and European seabass, gilthead seabream, Mediterranean mussel, and Japanese carpet shell in marine waters. Three main farming systems are found in Italy: extensive fish culture (ponds, confined coastal lagoons, "valli"), intensive fish culture (land-based, inshore and offshore cages) and shellfish culture (suspended and bottom culture)[14].

Several opportunities for higher education are offered related to employment, knowledge and Research. The Ministry of Education, University and Research is responsible for some issues related to research planning, education and training in capture fisheries and aquaculture. Studies in Aquaculture in Italy can be delivered in different educational levels and Institutions public universities, legally recognized non-public universities, higher schools and institutions with special charter), providing students either with a Biology, Animal Science or Veterinary background that could further advance in specialized knowledge in aquaculture. University study courses are structured in credits (CFU) which is equivalent to the ECTS system[15].

First cycle-Bachelor studies

The first level of higher education in Italy is the *Laurea Triennale*, which is equivalent to a bachelor's degree with a duration of three years[15]. Italy offers undergraduate programs in Biology, Animal Science, Veterinary Science, where courses as Ichthyology, fish physiology, fish pathology, which are integrated within study programs. These courses have the objective to provide students with sufficient knowledge of general methods scientific content and professional knowledge. There are also more specialized bachelor programs related to Marine Biology, Fisheries and Aquaculture, where students learn about marine organisms and aquatic ecosystems, biodiversity and conservation, as well as fisheries, aquaculture systems and the related policy, with a focus on sustainable management practices.

These undergraduate programs typically take three years to complete and may include a combination of lectures, laboratory work, fieldwork, and internships. Upon completion, students are awarded a Bachelor's degree (Laurea) preparing them for careers in the aquaculture industry or further study in related fields of the respective discipline.

Second cycle- Master's degree

The Laurea Magistrale is the second level of higher education in Italy, equivalent to a master's degree and it can be delivered in one- or two-years studies. The curricula of the Master's Degree have been conceived to provide a more specialized and in-depth study as well as a broad range of professional skills and competencies[14]. Each program may have specific admission requirements, teaching language, curriculum structures, and research opportunities. Upon completion, students are awarded a Master's degree (Laurea Magistrale) in their chosen field.

[14] https://www.fao.org/fishery/en/countrysector/it/en
[15] https://www.cimea.it/EN/pagina-il-sistema-italiano-d-istruzione-superiore

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Master's degree offers in Italy related to Aquaculture, are multiple. Some focus on the scientific principles and practical aspects of aquaculture systems and fisheries or in a multidisciplinary approach, covering topics such as marine biology, fish nutrition, seafood safety, as well as aquaculture economics and management.

Vocational training

Besides the qualifications listed above, Italian universities can institute other courses which comprise the category of lifelong learning or continuous education[16], known as "Corsi di perfezionamento". Publicly funded vocational education and training courses are offered by the Ministry of Agriculture, Food and Forestry Policies (MiPAAF), by the public veterinary institutes, the National Institute of Health, universities, agencies or accredited regional authorities and producers' organisations. The structure of each course and admission qualification are decided autonomously by each university or public authorities. Regional authorities, may also plan activities with state schools (technical and professional) or universities[17], delivered at specific seasonal periods.

The duration is usually between two months and one year, but there are offers with a duration up to three years. In Italy, vocational studies related to aquaculture are available through specialized training programs and institutes. Continuing education options may include university-level programs in aquaculture or related thematics, as well as summer schools, workshops, seminars, and certifications offered by industry organizations.

The curriculum in aquaculture vocational programs covers a range of topics relevant to the industry, including the farming of fish, shellfish, and aquatic plants, water quality management, aquaculture business management, and environmental sustainability. Practical training may include hands-on experience in fish farms, hatcheries, and in research laboratories.

Vocational institutes offering aquaculture programs often collaborate closely with industry partners, including commercial aquaculture operations, research institutions, government agencies, and non-profit organizations. The Italian government provides support for vocational education and training through various initiatives and funding programs.

Upon completing their vocational studies in aquaculture, students may receive diplomas or certificates that recognize their proficiency in the field and they can enhance students' employment prospects in the aquaculture sector.

Graduates of aquaculture vocational programs in Italy may choose to further their education through higher-level courses or pursue opportunities for professional development and specialization.

Overall, higher education and vocational studies in Italy play a vital role in preparing students for careers in the aquaculture sector by providing with both theoretical knowledge and practical skills, contributing to the sustainability and growth of the aquaculture industry in Italy.

[16] https://www.cedefop.europa.eu/en/tools/apprenticeship-schemes/scheme-fiches/apprenticeship-vocational-qualification-and

[17] Casalone, G.; Baici, E. Education, Off-the-Job Vocational Training, and Early Employment Outcomes: Evidence from Italy. Merits 2023, 3, 390–404. https://doi.org/10.3390/merits3020022

3.12 Malta

Aquaculture in Malta is marine-based and it consists of the capture-based aquaculture of the Atlantic bluefin tuna (*Thunnus thynnus*), as well as the culture of European sea bass (*Dicentrarchus labrax*) and Gilthead Sea bream (*Sparus aurata*) with a small production of Meagre (*Argyrosomus regius*) and amberjack (*Seriola dumerili*). Aquaculture of seabass, seabream and meagre takes place in floating cages, approximately one kilometre offshore while the tuna farms are approximately 6 km offshore[18].

Aquaculture education in Malta spans various levels, from foundational bachelor's programs to advanced master's degrees and practical vocational training. This comprehensive educational framework supports the development of skilled professionals capable of driving innovation and sustainability in Malta's aquaculture industry. By providing a blend of theoretical knowledge and practical experience, Maltese educational institutions play a crucial role in the growth and advancement of the aquaculture sector, which is vital to the country's economy and environmental management efforts.

First cycle-Bachelor studies

In Malta, the first cycle of aquaculture education is offered through bachelor's degree programs at Universities and specialized Institutions. These programs provide students with a foundational understanding of aquaculture, marine biology and environmental science. Key courses include fish biology, aquaculture systems and technology, marine ecology, and sustainable aquaculture practices. Students are also taught about the economic and regulatory aspects of the aquaculture industry, which is a significant sector in Malta. Practical experience is a crucial component, with students engaging in laboratory work, field trips and internships at local aquaculture facilities. The University of Malta, particularly through its Institute of Earth Systems, offers a bachelor's degree in applied sciences with a focus on aquaculture.

Second cycle- Master's degree

For advanced education, Malta offers master's degree programs that provide in-depth knowledge and specialized skills in aquaculture. These second cycle programs cover advanced topics such as fish nutrition and health management, genetic improvement, aquaculture engineering and environmental impact assessment. The curriculum combines advanced coursework with research projects and practical training, often involving collaboration with industry partners and research institutions. These programs aim to develop expertise that prepares graduates for leadership roles in research, industry, or policy-making. The University of Malta offers a Master of Science (MSc) in Sustainable Aquaculture, focusing on sustainable practices and innovative technologies in the aquaculture sector.

Vocational training

Vocational training in aquaculture in Malta is designed to provide practical, hands-on education for individuals looking to enter the workforce quickly. These programs are offered by vocational schools, technical colleges, and specialized training centres. Vocational courses cover essential skills such as fish farming techniques, hatchery management, water quality monitoring, and maintenance of aquaculture equipment. Training is closely aligned with industry needs, ensuring that graduates are well-prepared for employment in Malta's aquaculture sector. Practical experience is emphasized, with students gaining hands-on training through apprenticeships and

[18] https://www.fao.org/fishery/en/countrysector/mt/en?lang=en

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placements at local aquaculture businesses. Malta College of Arts, Science & Technology (MCAST) offers vocational courses and diplomas in aquaculture, providing comprehensive training tailored to industry requirements.

3.13 Norway

Salmon and rainbow trout farming have developed into significant operations along much of Norway's coastline.

Atlantic salmon (*Salmo salar*, an anadromous species, native to Norwegian waters), is by far the most important species in Norwegian aquaculture. Intensive farming of Atlantic salmon is by far the most important activity[19]in Norway. Rainbow trout (*Oncorhynchus mykiss*) is the only fish species in Norwegian aquaculture that is not native. Salmon and rainbow trout are anadromous species, meaning they have life stages in both freshwater and seawater. For salmon, hatching and smolt production occur in freshwater tanks on land, while intensive rearing to commercial size takes place in sea cages.

Gadus morhua, commonly known as cod, has historically been the most important species in Norwegian fisheries. Due to seasonal variations in availability and fluctuations in annual catches, the significance of farming this species has become evident. After many years of research, cod production is now expanding rapidly. Egg hatching of marine species such as cod also takes place in terrestrial tanks whose water is pumped from the sea; breeding is then carried out more or less in the same way as salmonids[18].

Atlantic halibut *(Hippoglossus hippoglossus*) and spotted wolffish (*Anarhichas minor*) are considered very interesting as a prospect for aquaculture. All of these species are now commercially available.

Mussels (*Mytilus edulis*) are found along the entire Norwegian coast. Various experiments in extensive aquaculture of this species have been carried out over for several years, however, production has not yet reached commercial profitability. Mussels farming is more extensive with the collection of natural spat and growth on lines.

Oyster cultivation (*Ostrea edulis*) has been practiced for over a hundred years, involving both juvenile and commercial-sized oysters. Interest in other shellfish is recent as the Pacific oyster (*Magellan gigas*) which was imported for aquaculture purposes, but neither reached a significant production volume. Experiments in the cultivation of the large Atlantic scallop (*Pecten maximus*) are also underway and have been for several years but no commercial production has yet been established[18].

Aquaculture education in Norway encompasses a range of programs, from foundational bachelor's degrees to advanced master's degrees and practical vocational training. This comprehensive educational framework supports the development of skilled professionals capable of advancing the aquaculture industry, which is a cornerstone of Norway's economy and global aquaculture leadership. By providing both theoretical knowledge and practical experience, Norwegian educational institutions play a crucial role in driving innovation, sustainability and growth in the aquaculture sector.

[19] https://www.fao.org/fishery/en/countrysector/no/fr?lang=fr

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First cycle-Bachelor studies

In Norway, the first cycle of aquaculture education is offered through bachelor's degree programs at Universities and specialized Institutions. These programs provide students with a comprehensive understanding of aquaculture science, technology, and management. Core subjects typically include fish biology, aquaculture systems design, water quality management, feed technology and fish health. Students also learn about the economic and regulatory aspects of the aquaculture industry, which is a significant contributor to Norway's economy. Practical experience is emphasized, with students participating in laboratory work, field studies and internships at aquaculture facilities. Notable institutions offering bachelor's programs in aquaculture include the Norwegian University of Life Sciences (NMBU) and the University of Bergen, both of which have strong programs in marine sciences and aquaculture.

Second cycle- Master's degree

For advanced education, Norway offers master's degree programs that delve deeper into specialized areas of aquaculture. These second cycle programs cover advanced topics such as fish nutrition, breeding and genetics, aquatic animal health, aquaculture engineering and environmental management. The curriculum includes both theoretical coursework and practical training, with students often engaging in research projects and collaborations with industry partners. Master's programs aim to develop expertise that prepares graduates for leadership roles in research, industry, or policy-making. Institutions such as the Norwegian University of Science and Technology (NTNU) and the University of Tromsø offer comprehensive master's programs in aquaculture, focusing on sustainable practices and innovation in the industry.

Vocational training

Vocational training in aquaculture in Norway is designed to provide practical, hands-on education for individuals seeking to enter the aquaculture workforce directly. These programs are offered by vocational schools, technical colleges and specialized training centres. Vocational courses cover essential skills such as fish husbandry, hatchery operations, fish health management and aquaculture equipment maintenance. Training often includes apprenticeships or practical placements at aquaculture farms and hatcheries, allowing students to gain real-world experience under the guidance of industry professionals. Norway's vocational training system is highly regarded for its quality and relevance to industry needs, ensuring that graduates are well-prepared for successful careers in aquaculture.

Vocational training for aquaculture in Norway is provided by several institutions and organizations dedicated to delivering practical, job-oriented education tailored to the needs of the aquaculture industry. Some of the key providers of vocational training for aquaculture in Norway include:

Vocational Schools and Technical Colleges

Vocational schools and technical colleges across Norway offer specialized courses and programs in aquaculture. These programs cover essential skills such as fish biology, water quality management, aquaculture systems design and equipment maintenance, preparing students for entry-level positions in the aquaculture sector.

Aqua-UiT – Centre of Excellence in Aquaculture Learning

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Aqua-UiT, based at UiT The Arctic University of Norway, offers vocational training and continuing education programs in aquaculture. These programs are designed to meet the needs of both new entrants to the industry and experienced professionals seeking to update their skills and knowledge.

Agricultural and Aquaculture Training Centres

Various agricultural and aquaculture training centres in Norway provide vocational training programs in aquaculture. These centres offer hands-on training and practical experience in fish farming techniques, aquaculture management and sustainable aquaculture practices, preparing students for employment in the aquaculture industry.

3.14 Poland

Aquaculture in Poland is part of the inland fisheries sector and relies entirely on the cultivation of freshwater species, primarily common carp (*Cyprinus carpio*) and trout (*Oncorhynchus mykiss*) [20]. Poland is the largest producer of these species in Europe, accounting for about 15% of European production. Additionally, other herbivorous species are cultured alongside carps in polyculture systems. These include grass carp (*Ctenopharyngodon idella*), bighead carp (*Aristichthys nobilis*), willy's catfish (*Silurus glanis*), tench (*Tinca tinca*) and Persian carp (*Carassius gibelio*). Fish rearing and cultivation in Poland are mainly conducted in earthen ponds.

In addition to producing fish for consumption, Polish aquaculture also generates stocking material for migratory (anadromous), rheophilous, and predatory fish, including Northern pike (*Esox lucius*), zander (*Sander lucioperca)* and wels catfish *(Silurus glanis*). The increasing demand for this type of material in recent years has driven the development of fish farms and the modernization of hatcheries and rearing facilities.

Fish production in recirculating systems occurs at numerous farms. These systems are primarily used to produce stocking material for aquaculture and to stock open waters. Polish carp pond fisheries serve as an effective tool for protecting native ichthyofauna (regional fish species) and maintaining aquatic ecosystem biodiversity[20].

Poland's aquaculture sector is managed by well-trained professionals. The country also boasts a well-developed education system specializing in fisheries and aquaculture.

In Poland, higher education opportunities in aquaculture intersect with employment prospects, knowledge acquisition, and research pursuits. The sector is gaining prominence in response to the growing demand for sustainable seafood production. Poland offers a diverse range of academic programs in aquaculture across various educational levels and institutions. These encompass public universities, higher education establishments, and specialized research institutions.

Students enrolled in these programs undergo comprehensive coursework covering a wide array of disciplines, including biology, fish biology, veterinary sciences, ecology, freshwater or marine sciences, and animal breeding. The academic framework in Poland follows the European Credit Transfer and Accumulation System (ECTS), ensuring standardized credit allocation across university courses.

[20] https://www.fao.org/fishery/en/countrysector/pl/en?lang=en

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First cycle-Bachelor studies

In Poland, first-cycle Bachelor (Licencjat) studies in aquaculture are typically part of broader programs in marine sciences, fisheries, or agricultural sciences. These programs provide students with a comprehensive understanding of aquaculture principles, practices, and techniques, as well as broader knowledge in related fields such as biology, fisheries, and animal breeding.

Bachelor (Licencjat) programs in aquaculture in Poland typically span three to four years of full-time study and are offered by universities, technical institutes, and specialized technology schools across the country. Students may enrol in programs such as Bachelor of Ichthyology and Aquaculture or Bachelor of Zootechnics and Fisheries.

The curriculum of these programs covers a wide range of topics relevant to aquaculture, including fish biology, aquatic ecology, aquaculture systems and technologies, water quality management, nutrition and feed formulation, environmental sustainability, and fisheries.

Upon successful completion of the Bachelor studies in aquaculture or related fields, students are awarded a Bachelor's (Licencjat) degree in the respective discipline. This qualification prepares graduates for various entry-level positions in the aquaculture industry, including fish farming, hatchery operations, aquaculture research, environmental consulting, and governmental or non-governmental organizations involved in aquatic resource management.

Second cycle- Master's degree

In Poland, postgraduate studies in aquaculture are available at master's levels, offering advanced education and research opportunities for individuals seeking to deepen their knowledge and expertise in this field.

Master's Degree (Tytuł magistra):

Master's degree programs in aquaculture typically last one to two years and are offered by universities and throughout Poland. These programs provide students with advanced training in various aspects of aquaculture, including sustainable production techniques, resource management, environmental impact assessment, and aquaculture policy and regulation.

On successful completion of a master's degree program in aquaculture, graduates are awarded a Master's degree (Tytuł magistra) in the respective discipline. This qualification prepares graduates for leadership roles in the aquaculture industry, research institutions, government agencies, non-governmental organisations, and international organisations involved in fisheries and aquaculture management.

Vocational training

In Poland, vocational training in aquaculture is provided by various institutions, including technical institutes, and specialised aquaculture training centres. These programs are designed to provide practical, hands-on training to individuals interested in pursuing a career in the aquaculture industry.

Vocational training for aquaculture in Poland covers a wide range of topics relevant to the sector, including fish farming techniques, hatchery operations, aquaculture systems and equipment, marine chemistry, water quality management, oceanography, environmental sustainability practices and in research laboratories.

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Upon completion of vocational aquaculture training programs, graduates are equipped with the knowledge and skills needed to obtain entry-level positions in various sectors of the aquaculture industry, including fish farms, hatcheries, aquaculture equipment suppliers and environmental consulting firms.

3.15 Romania

The fisheries sector in Romania, includes aquaculture, marine and inland fishing activities and related processing and marketing activities. The main component of Romania's fish production is aquaculture, followed by inland fisheries. Fishing activities along the Black Sea coast are still limited compared to inland fisheries. Over 70 000 ha are used in Romania as fish ponds and represent a great advantage for the development of aquaculture in the Country[21].

In Romania, aquaculture stocks are dominated by carps (*Cyprinus carpio*), Silver Car (*Hypophthalmichthys molitrix*), bighead carp (*Aristichthys nobilis*), grass carp (*Ctenopharyngodon idella*), goldfish (*Carassius auratus*), Black Carp (*Carassius Carassius*). In addition, rainbow trout (*Oncorhynchus mykiss)* and sea trout *(Salmo trutta)* are reared, followed by perch, pike, catfish and freshwater sturgeon (15%). Romania has traditionally used extensive or semi-intensive systems. The rearing tanks used are traditional water flow tanks similar to those in trout farms, and earth basins (stews or ponds) for cyprinids. Aquaculture utilizing floating cages or recirculating systems has only been introduced in recent years.

Marine aquaculture is still in its infancy, producing only Mediterranean mussels (*Mytillus galloprovincialis*). However, the development of this sub-sector is attractive and possible.

In order to increase the productivity of the fish farms, most of them will be modernized. Particular attention is given to the process to be directed to the trout culture in mountain areas, to increase the income of local people.

In Romania, higher education opportunities in aquaculture intersect with employment prospects, knowledge acquisition, and research pursuits. This sector is on the rise in response to the increase in demand for sustainable seafood production. Romania offers a diverse range of academic programs in aquaculture across various educational levels and institutions. These encompass public universities, higher education establishments, and specialized research institutions.

Students enrolled in these programs undergo comprehensive coursework covering a wide array of disciplines, including biology, fish biology, veterinary sciences, ecology, freshwater or marine sciences, and biotechnology. The academic framework in Romania follows the European Credit Transfer and Accumulation System (ECTS), ensuring standardized credit allocation across university courses.

First cycle-Bachelor studies

In Romania, first-cycle Bachelor (Bacalaureat) studies in aquaculture are typically part of broader programs in food science and engineering, fisheries, or veterinary medicine. These programs provide students with a comprehensive understanding of aquaculture principles, practices, and techniques, as well as broader knowledge in related fields such as biology, fisheries, nutrition and animal breeding.

[21] https://www.fao.org/fishery/en/countrysector/ro/en?lang=en

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Bachelor (Bacalaureat) programs in aquaculture in Romania typically span three to four years of full-time study and are offered by universities, technical institutes and specialized technology schools across the country. Students may enrol in programs such as Bachelor of Animal science or Bachelor of Fisheries and Aquaculture.

The curriculum of these programs covers a wide range of topics relevant to aquaculture, including fish biology, aquatic ecology, aquaculture systems and technologies, water quality management, nutrition and feed formulation, environmental sustainability and fisheries.

Upon successful completion of the Bachelor studies in aquaculture or related fields, students are awarded a Bachelor's (Bacalaureat) degree in the respective discipline. This qualification prepares graduates for various entry-level positions in the aquaculture industry, including fish farming, hatchery operations, aquaculture research, environmental consulting and governmental or non-governmental organizations involved in aquatic resource management.

Second cycle- Master's degree

In Romania, postgraduate studies in aquaculture are available at master's levels, offering advanced education and research opportunities for individuals seeking to deepen their knowledge and expertise in this field.

Master's degree programs (Masterat) in aquaculture typically last one to two years and are offered by universities and throughout Romania. These programs provide students with advanced training in various aspects of aquaculture, including sustainable production techniques, resource management, environmental impact assessment, aquaculture policy and regulation, food engineering, food control and fish nutrition.

On successful completion of a master's degree program in aquaculture, graduates are awarded a Master's degree (Masterat) in the respective discipline. This qualification prepares graduates for leadership roles in the aquaculture industry, research institutions, government agencies, non-governmental organisations and international organisations involved in fisheries and aquaculture management.

Vocational Training

In Romania, no vocational training for aquaculture have been identified.

3.16 Spain

Spain is a major player in European aquaculture, ranking first in terms of harvest volume and fourth in terms of value. Spain primarily cultivates mussels where approximately 70% of the Spanish mussel production is destined for internal consumption, and the resulting 30% is exported, mainly to Italy and France[22]. Mussels are cultivated on sea barges and longlines. The production of sea fish has experienced an important growth during the past few years. This growth is due mainly to the seabass (*Dicentrarchus labrax*) and the seabream (*Sparus aurata*), which are reared in offshore cages. Other marine fish species cultivated at a commercial level include: turbot (*Psetta maxima*), European eel (*Anguilla anguilla*) in some Spanish areas, blackspot seabream (*Pagellus bogaraveo*), meagre (*Argyrosomus regius*), common sole (*Solea vulgaris*) and tilapia. Species are on an advanced research stage as the red seabream or snapper, the common seabream (*Pagrus pagrus*) or red mullet (*Mullus* spp.) and the octopus (*Octopus vulgaris*)[21].

[22] https://www.fao.org/fishery/en/countrysector/es/en?lang=en

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The development of inland aquaculture, is still expanding being a success story and is based on trout production due to the high quality of the country's freshwater resources. Cultivation of other continental species has developed at a much smaller scale, located geographically according to environmental conditions and the regions' particular consumption habits.

Semi-intensive farming is carried out in estuaries and in abandoned salt pans, while intensive farming is realised in concrete or plastic tanks.

Aquaculture has experienced the highest growth in food production over the past 30 years and is now a well-integrated activity capable of meeting the increasing demand for fishery products. Spain ranks as the second-largest producer in Europe, the fifth-largest producer of shellfish worldwide, and a significant producer of trout, turbot, sea bream, and sea bass. The great development of inland aquaculture, which is still expanding, has primarily been driven by trout production, owing to the high quality of the country's aquatic resources. In the realm of marine aquaculture, the production of sea fish has seen significant growth in recent years, particularly due to seabass and seabream.

The demand for aquaculture in Spain is significant and growing, driven by high seafood consumption, sustainability needs, and economic factors that underscore the importance of this sector:

- Spain has one of the highest per capita seafood consumption rates in Europe. The Spanish diet traditionally includes a substantial amount of fish and shellfish, creating a strong domestic market for aquaculture products.

- Overfishing and depletion of wild fish stocks have heightened the need for sustainable sources of seafood. Aquaculture provides a reliable and controlled means of producing fish and shellfish without further straining natural resources.

- Aquaculture is a vital part of Spain's economy, particularly in coastal regions. It generates employment and supports local communities, contributing significantly to regional development and economic stability. Spanish aquaculture products are in demand not only domestically but also in international markets. Spain exports a significant portion of its aquaculture produce to other European countries and beyond

- Innovations in aquaculture technology and practices have improved the efficiency and productivity of fish farms, making aquaculture more viable and attractive as a source of high-quality seafood.

- The European Union's Common Fisheries Policy (CFP) and various funding programs support the development of sustainable aquaculture practices. This regulatory support helps drive investment and growth in the sector.

- With growing awareness of environmental issues, there is a demand for sustainable and environmentally friendly aquaculture practices. Consumers are increasingly looking for seafood that is produced with minimal environmental impact.

In a growing demand for graduate professionals in aquaculture, Spain offers a comprehensive educational pathway in marine sciences and aquaculture, starting from undergraduate studies to advanced graduate research and vocational training. These programs equip students with the theoretical knowledge and practical skills needed to contribute effectively to the marine and aquaculture sectors.

First cycle-Bachelor studies

Courses related to aquaculture are offered mainly in the broad fields of biological, environmental, marine or animal sciences, as part of their curricula.

Bachelor's studies generally last for four years, or a duration of 240 credits. They are using a transdisciplinary approach, offering a broad-base, and comprehensive understanding in related fields, like biology, ecology, living resources, and some aspects of fisheries & aquaculture.

Throughout the Bachelor studies, students are engaged in a combination of theoretical course and laboratory work, and potentially in fieldwork and working experience either at the university or in related companies.

Upon successful completion of the first-cycle bachelor studies, students are awarded a bachelor's degree in the respective discipline, preparing them for careers or further studies in related fields of their disciplines.

Second cycle-Master's studies

Master's programs typically span one to two years of full-time study, and may have specific admission requirements, teaching language, curriculum structures, and research opportunities. These programs provide students a high-level vision of theoretical and applied knowledge in the fundamental aspects of the biology of marine species, fishing, farming, sustainable production techniques, environmental management and general economics of the current state of aquaculture and fishing, as well as new technologies used in the most relevant aspects of aquaculture and fishing, cultivating a skilled workforce for the aquaculture industry.

Upon completion, a Master's degree in the respective discipline is awarded.

Vocational Training

Furthermore, there are several vocational training centres that provide specialized education and training in aquaculture. These centres offer programs that combine theoretical knowledge with the practical skills required for a career in the aquaculture industry, focusing on hands-on training in fish farming, marine species breeding, and environmental management. They are organized and taught either by governmental entities or by research institutions or companies and associations related to aquaculture research. Such training courses usually consist of two cycles, each lasting two years, training Technicians in either Aquaculture Production or Aquaculture Operation.

In Spain, vocational training for aquaculture is offered by various institutions and organizations that specialize in fisheries, aquaculture and marine sciences. Here are some examples of providers of vocational training for aquaculture in Spain:

Spanish Institute of Oceanography (IEO - Instituto Español de Oceanografía)

The IEO offers vocational training programs in aquaculture through its various research centers located across Spain. These programs cover a wide range of topics, including fish biology, aquaculture technology, marine ecology and fisheries management. The IEO's vocational training is known for its practical focus and industry relevance.

Aquaculture Technology Centers (CTAs - Centros Tecnológicos de Acuicultura)

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CTAs are specialized research and training centers dedicated to aquaculture technology and innovation. These centers offer vocational training programs in aquaculture, focusing on practical skills such as fish farming techniques, hatchery management, water quality monitoring, and aquaculture systems design.

Universities and Research Institutions

Several universities and research institutions in Spain offer vocational training programs in aquaculture as part of their undergraduate and postgraduate curriculum. These programs provide students with hands-on training in aquaculture practices and technologies, preparing them for careers in the aquaculture industry or further academic study.

Vocational Training Schools (Escuelas de Formación Profesional)

Vocational training schools across Spain may offer specialized courses or training modules in aquaculture. These programs focus on practical skills and may include internships or work placements at aquaculture facilities to provide students with real-world experience.

3.17 The Netherlands

The Netherlands has a well-established aquaculture industry, but it focuses more on shellfish farming compared to finfish. The shellfish sub-sector is the older and economically more significant, where blue mussels (*Mytilus edulis*) and oysters (*Ostrea edulis* and *Crassostrea gigas*) are reared[23]. Mussels are filter feeders and don't require constant feeding. The shellfish sector relies on natural oyster spat fall and the collection of mussel seed from natural populations. Mussel seed collection takes place in areas of great natural value where strict conditions and monitoring are applied. They are often cultivated on bottom culture (lines anchored to the seabed), sea bottom lines suspended in the water column, or on rafts.

The Aquaculture of finfish occurs in heated recirculation aquaculture systems (RAS) and in outdoor rainbow trout farms. The most popular species are European eel (*Anguilla anguilla*), African catfish (*Clarias gariepinus*) and tilapia (*Oreochromis niloticus*). Moreover, in indoor heated systems, turbot (*Scophthalmus maximus*), sole (*Solea solea*), barramundi (*Lates calcarifer*), pike-perch (*Stizostedion lucioperca*) and whiteleg shrimp (*Penaeus vannamei*) are grown in by a small number of pioneering farms.

Most finfish farmers gained their knowledge through a minor subject in agricultural trade school or by attending special short courses (trade school level). University graduates with a degree in biology, fish culture or animal husbandry form a minor but significant part of eel and catfish farmers. Women form a small minority among finfish farm owners and personnel and this underrepresentation is even more pronounced in the shellfish sub-sector[23].

Aquaculture education in the Netherlands encompasses a range of programs, from foundational bachelor's degrees to advanced master's degrees and practical vocational training. This comprehensive educational framework supports the development of skilled professionals capable of advancing the aquaculture industry, which plays a crucial role in the Dutch economy and global aquaculture leadership. By providing both theoretical knowledge and practical experience, Dutch educational institutions contribute significantly to the growth, innovation, and sustainability of the aquaculture sector.

[23] https://www.fao.org/fishery/en/countrysector/nl/en?lang=en

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First cycle-Bachelor studies

In the Netherlands, the first cycle of aquaculture education is offered through bachelor's degree programs at universities and specialized institutions. These programs provide students with a comprehensive understanding of aquaculture science, technology, and management. Core subjects typically include fish biology, aquaculture systems design, water quality management, feed technology and fish health. Students also learn about the economic and regulatory aspects of the aquaculture industry, which is a significant contributor to the Dutch economy. Practical experience is emphasized, with students participating in laboratory work, field studies, and internships at aquaculture facilities. Notable institutions offering bachelor's programs in aquaculture include Wageningen University & Research and the University of Groningen, both of which have strong programs in aquatic sciences and aquaculture.

Second cycle- Master's degree

For advanced education, the Netherlands offers master's degree programs that provide in-depth knowledge and specialized skills in aquaculture. These second cycle programs cover advanced topics such as fish nutrition, breeding and genetics, aquatic animal health, aquaculture engineering, and environmental management. The curriculum includes both theoretical coursework and practical training, with students often engaging in research projects and collaborations with industry partners. Master's programs aim to develop expertise that prepares graduates for leadership roles in research, industry, or policy-making. Institutions such as Wageningen University & Research and the University of Amsterdam offer comprehensive master's programs in aquaculture, focusing on sustainable practices and innovation in the industry.

Vocational training

Vocational training in aquaculture in the Netherlands is designed to provide practical, hands-on education for individuals seeking to enter the aquaculture workforce directly. These programs are offered by vocational schools, technical colleges, and specialized training centres. Vocational courses cover essential skills such as fish husbandry, hatchery operations, fish health management, and aquaculture equipment maintenance. Training often includes apprenticeships or practical placements at aquaculture farms and hatcheries, allowing students to gain real-world experience under the guidance of industry professionals. Dutch vocational training is known for its quality and relevance to industry needs, ensuring that graduates are well-prepared for successful careers in aquaculture.

C. Outermost European Union Regions in the Atlantic Ocean

The French Outermost Regions in the Atlantic Ocean include French Guiana, Réunion, Guadeloupe and Martinique. While each region has its specific characteristics and challenges, aquaculture plays a significant role in food security, economic development and sustainable resource management.

3.18 French Guiana

French Guiana, located on the northeastern coast of South America, has significant potential for aquaculture development due to its extensive coastline and rich biodiversity. The region's aquaculture activities focus on shrimp farming, with the cultivation of species such as *Litopenaeus vannamei* (whiteleg shrimp). Sustainable aquaculture practices and research are priorities for the development of the sector in French Guiana.

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Context

There's a certain dynamic around this sector with the intention to implement new training courses by several structures by 2025 and to respond to the needs of the aquaculture sector. There are currently no bachelor or post graduate courses in aquaculture in French Guiana.

The EPLEFPA (Local public establishments for agricultural education and vocational training) and the MFR (Maison Familiale et Rurale) are in the process of creating professional CAPs and/or baccalaureates in fisheries (sailor; yachting; trade) and aquaculture to reply to the need of qualified labour on the territory.

Vocational studies

One of municipalities of the savannah region has the ambition to work on **structuring and developing the major blue economy sector and its sustainable maritime and river tourism**, which aims to create more blue jobs, and raise awareness among young people.

What training courses

Already present throughout France, these structures offer training through school, apprenticeship, professionalization contract or continuous education. Courses start as early as 4th grade and go on to lead to CAP, BEP, vocational or technological BACs, BTS and professional licenses, as well as certificates of specialization in a wide range of fields, including agriculture, livestock breeding, land development, the hotel industry, tourism, etc.

The positioning of an MFR in these regions makes perfect sense, given that the savannah region has no alternative structure for initial and continuous training. One of the MFR also aims:

- To create a processing plant for fishing and aquaculture products and to valorize more its by-products;
- To become French Guiana's 2nd largest seaport.

These students may receive diplomas or certificates that recognize and value their skills/qualifications in the field. All these training courses will enable in the future the creation of higher-grade courses on the territory and will bring young people closer to the educational system and help them to choose the best career while reaching the objectives of development of the local communities.

3.19 Guadeloupe

Guadeloupe situated in the Caribbean Sea, has well-established aquaculture sectors that contribute to local food production and economic development. Fish farming is predominant, with tilapia and shrimp being the main species cultivated. Additionally, there are initiatives to promote sustainable aquaculture practices and diversify production to include shellfish farming and seaweed cultivation.

The aquaculture Park of Guadeloupe

The Aquaculture Park is a site dedicated to sustainable aquaculture production. Since 1999, they have been rearing ouassous, Creole red mullet and, off the coast of Pointe Noire in Guadeloupe, Caribbean wolfish (red drum) in ponds. They also produce their own juveniles in the hatchery, and control every stage of the farming process, from egg to plate.

Young students/children may visit the aquaculture park, which enables teachers to work on themes relating to water and the development of aquaculture: aquatic life, biology and behavior of farmed species, physiological cycles and functions, and the issues and challenges facing development in the future.

https://www.parc-aquacole.fr/activites/ferme-pedagogique/

First cycle-Bachelor studies

The West Indies University offers a professional degree in maritime professions Ecological restoration and sustainable development.
As for career opportunities, these students can become:
- Specialist technician, assistant to the engineer in a design office, laboratory, local authority or company providing services in the field of the environment and sustainable development;
- Middle manager, project manager;
- Middle manager, specialised technician in water and wastewater treatment companies, aquaculture companies and companies involved in the agro-processing of marine resources;
- Sustainable development officer in ecotourism, in the nautical sector, transport and maritime works.

3.20 Martinique

Martinique situated in the Caribbean Sea, has well-established aquaculture sectors that contribute to local food production and economic development. Fish farming is predominant, with tilapia and shrimp being the main species cultivated. Additionally, there are initiatives to promote sustainable aquaculture practices and diversify production to include shellfish farming and seaweed cultivation.

The aquaculture industry got off the ground in 1982 following work carried out by ADAM (the association for the development of marine aquaculture) and IFREMER (the French institute for research and exploitation of the sea) on the development of the farming of Caribbean wolfish (*Sciaenops ocellata*). Today, this is the only species farmed in Martinique.

3.21 Mayotte

The marine park of Mayotte

Created in 2010, includes a surface of 69 000 km2, and aims to conciliate protection of the local marine environment and sustainable development.

Every year, the Park launches a call for educational projects aimed at schools, enabling almost 3,000 pupils to discover the riches of the marine environment.

Depending on the objectives and needs of each project, the Park provides human, material and/or financial support in the form of:

- classroom activities based on the targeted themes;
- educational outings at sea;
- educational activities run by local associations that are partners of the Park.

In general terms, although the list is not exhaustive, the call for projects enables pupils to benefit from a variety of activities, such as:

- snorkelling trips to discover the fringing reef;
- outings to explore the mangroves on foot or in a kayak;
- first dives;
- sea outings to observe the reef from a glass-bottomed boat;
- sea outings to observe the marine fauna and discover Mayotte's islets and beaches.

https://parc-marin-mayotte.fr/

3.22 La Reunion

La Réunion has indicated that they have no training courses in aquaculture since 2018.

HYDRO REUNION

Since 2007, Hydrô Réunion has had the status of a Technology Resource Centre (TRC), a label awarded by the French Ministry of Higher Education, and therefore operates as a CRITT (Centre for Resources and Technical and Technological Innovation).

CITEB, is the technical centre for research and development of aquatic environments, which carries out studies on aquaculture in La Réunion.

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Annex 1. The Countries matrix (Excel file)

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