An overview of aquaculture education in the Nordic countries, with special emphasis on recirculating aquaculture systems (RAS)

Prepared by
Hanna Ahonen and Juhani Pirhonen
University of Jyväskylä, Department of Biological and Environmental Science
P.O. Box 35, 40014 University of Jyväskylä, Finland

e-mail:
hanna.s.ahonen@jyu.fi
juhani.pirhonen@jyu.fi

Contents

1. Aquaculture education offered in the Nordic countries 1
1.1. NORWAY 1
1.1.1. Universities 1
1.1.2. Vocational schools 5
1.2. DENMARK 6
1.2.1. Universities 6
1.2.2. Vocational school 6
1.2.3. Other training 7
1.2.4. Faroe Islands 7
1.3. FINLAND 8
1.3.1. Universities 8
1.3.2. Vocational schools 9
1.4. SWEDEN 10
1.4.1. Universities 10
University of Gothenburg, GU 10
1.4.2. Vocational schools 12
Lysekil University College 12
1.5. ICELAND 13
1.5.1. Universities 13
1.5.2. Vocational schools 14
1.6. AQFood - Aquatic food production - Safety & Quality 15
2. RAS-meeting discussion 16
2.1. NORWAY 17
2.2. DENMARK 17
2.3. FINLAND 18
2.4. SWEDEN 18
2.5. ICELAND 19
2.6. General issues regarding education of aquaculture, especially RAS: 19

1. Aquaculture education offered in the Nordic countries

The report compiles the education of aquaculture offered in the Nordic countries: Norway, Denmark, Finland, Sweden and Iceland. The situation of education was examined from the web pages of each educational institute in November 2017, and in some cases the institute was contacted directly.

1.1. NORWAY

1.1.1. Universities

Norwegian University of Life Sciences NMBU

https://www.nmbu.no/en

Master's degree programme in Aquaculture, 120 ects

- courses: Laboratory Course in International Aquaculture, part 1, 5 ects, Basic Aquaculture Engineering 5 ects, General Aquaculture - Animal Welfare and Health in Farmed Fish 10 ects, General Aquaculture - Nutrition 10 ects, General Breeding 10 ects, Product Quality in Aquaculture 5 ects, Laboratory Course in International Aquaculture, Part 2, 5 ects, Animal Breeding Plans 10 ects, Planning and Design of Intensive Fish Farms 10 ects, Aquaculture Nutrition 10 ects, Aquaculture - Breeding and Genetics 5 ects, Production Technology in Aquaculture 10 ects, Environmental Pollutants and Ecotoxicology - with term paper 15 ects, Product Quality, Meat, Milk and Eggs 10 ects, Fish Processing Technology 10 ects, International Economics 10 ects, Molecular Genomics 10 ects, Introduction to Animal Production and Fish Farming in Developing Countries 5 ects, Statistical Genomics 10 ects, Theory and Application of Inbreeding Management 10 ects, Product Quality, Meat and Fish 5 ects

PhD programme in Animal and Aquacultural Sciences , 180 ects

University of Nord

https://www.nord.no/en

Bachelor's degree programme of Aquaculture Management, 180 ects

- courses: Basic Chemistry 10 ects, Seafood 10 ects, Examen philosophicum 10 ects, Laboratory safety 0 ects, Labour Law 10 ects, Farming of Marine Fish 10 ects, Basic Cell Biology and fish physiology 10 ects, Water quality and Aquaculture Engineering 10 ects, Farming of Salmonids 10 ects, Introduction to financial mathematics 5 ects, Business Economics with Relevant Computer Software 7,5 ects, Fish Nutrition and Feeding 10 ects, Aquaculture Management 10 ects, Introduction to financial accounting 7,5 ects, Production planning and the Economics of Fish Farming 10 ects, Fish Health 10 SP ects, Management 10 ects, Placement in Norway in aquaculture management - Placement 20 ects, Placement abroad in aquaculture management - Placement 20 ects

Master's degree programme in Biology and Aquaculture, 120 ects

- courses: Laboratory safety master 0 ects, Scientific Communication and Research Methods 10 ects, Aquaculture Ecology 10 ects, HSE and risk assessment 0 ects, Laboratory safety master 0 ects, Scientific Communication and Research Methods 10 ects, Aquaculture Ecology 10 ects, Aquaculture Nutrition 10 ects, Aquatic Animal Health - Specialization - Aquaculture 10 ects, Fish quality and food safety - Specialization - Aquaculture 10 ects, Work placement in the aquaculture industry 10 ects

PhD in Aquatic Biosciences, 180 ects

- course: Aquatic Animal Immunology 5 ects

Aquaculture and Ecology ja Aquaculture and Marine Biosciences (semester package, Study level: One term programme), 30 ects

- courses: International Aquaculture Ecology 10 ects + elective courses 20 ects

Norwegian University of Science and Technology, NTNU

https://www.ntnu.edu/

Ålesund-campus

Bachelor i Biomarin Innovasjon, Biomarine innovation, 180 ects

- courses: Innføring i kjemi 10 ects, Grunnleggende matematikk 7,5 ects, Marin biologi 7,5 ects, Innovasjonsledelse 7,5 ects, Markedsføring 7,5 ects, Marin økologi 10 ects, Anvendt fysikk for Biomarin innovasjon 5 ects, Mikrobiologi og hygiene 7,5 ects, Innovasjonsprosesser 7,5 ects, Innføring i produktutvikling 7,5 ects, Grunnleggende bedriftsøkonomi og regnskap 7,5 ects, Entreprenørskap med venture cup 7,5 ects, Sjømatforedling 10 ects, Akvakultur 10 ects, Biomarin verdiskaping og forskning 5 ects

Trondheim-campus

Bachelor's degree programme in Marine Technology, Specialization: Marine Resources and Aquaculture, 180 ects

- courses: Sustainable Utilization of Marine Resources 7, 5 ects, Sea Loads 7,5 ects, Design Methods 7,5 ects, Finite Element Methods in Structural Analysis 7,5 ects, Safe Operation and Maintenance 7,5 ects, Biological Oceanography 7,5 ects, Marine Acoustics 7,5 ects, Marine Control Systems I 7,5 ects, Computational Heat and Fluid Flow 7,5 ects, Fatigue and Fracture of Marine Structures 7,5 ects, RAMS Engineering and Management 7,5 ects, Design of Marine Production Plants 7,5 ects, Oceanography 7,5 ects, Understanding and Quantifying Environmental Impacts on Ecosystems 7,5 ects, Underwater Engineering, Basic Course 7,5 ects, Marine Dynamics 7,5 ects, Marine Control Systems II 7,5 ects, Experts in Teamwork - Fishfarming, an Expanding Industry

Master's degree programme in Marine Coastal Development, Specialization: Aquaculture, 120 ects

- courses: Biological Oceanography 7,5 ects, Ocean Space: Marine Biogeochemical Processes 7,5 ects, Molecular Genetics 7,5 ects, Design Methods 7,5 ects, Risk Analysis and Safety Management of Maritime Transport 7,5 ects, Aquatic Food Processing and Technology 7,5 ects, Recirculating Aquaculture Systems RAS 7,5 ects, Experimental Marine Ecological Methods 7,5 ects, Marine Acoustics 7,5 ects, Biopolymers 7,5 ects, Evolutionary and Ecological Genetics 7,5 ects, Aquatic Food Supply Chain Management, Environment and Resources 7,5 ects, Safety and Human Health Effects of Aquatic Food 7,5 ects, Biochemical Engineering 7,5 ects, Marine Organic Environmental Chemistry 7,5 ects, Operations Research, Introduction 7,5 ects, Sea Loads 7,5 ects, Experts in Teamwork - Sustainable Aquaculture 7,5 ects, Design of Marine Production Plants 7,5 ects, Marine Juvenile Production 7,5 ects, Stress Physiology 7,5 ects, Food Chemistry 7,5 ects, Thermal and Process Engineering of Food 7,5 ects, Underwater Engineering, Basic Course 7,5 ects, Oceanography 7,5 ects, Marine Operations 7,5 ects, Genetic Toxicology 7,5 ects, Conservation Biology 7,5 ects, Marine Control Systems I 7,5 ects, Marine Resources and Aquaculture, Specialization Course 7,5 ects, Marine Resources and Aqua, Specialization Project 7,5 ects, Safety and Human Health Effects of Aquatic Food 7,5 ects, Aquaculture in the Ecosystem 7,5 ects, Advanced Aquatic Chemistry 7,5 ects, Aquatic Food Processing and Technology 7,5 ects, Aquatic Food Supply Chain Management, Environment and Resources 7,5 ects

Master's degree programme in Ocean Resources, Specialization: Aquaculture, 120 ects

- aims: Sea based aquaculture, recycling aquaculture and juvenile production, environment, welfare and health, aquaculture system design, enabling technologies for aquaculture

Master's degree programme in Ocean Resources, Specialization: Food science, 120 ects

- aims: Aquatic food production, Fish waste utilization, Seaweed processing

International master's degree programme in Marine Technology, Specialization: Marine Resources and Aquaculture, 120 ects

- courses: Marine Resources and Aquaculture, Utilization of Marine Resources, Marine Resources and Aqua: Specialization Project, Marine Control Systems I

University of Adger

https://www.uia.no/en

Master's degree programme Coastal Ecology, 120 ects

- course: Mariculture 5 ects

University of Bergen, UIB

http://www.uib.no/en

Master's degree programme in Aquaculture Biology, 120 ects

- courses: Fish nutrition, Fish Physiology, Seafood quality and safety, Nutritional analysis, Aquatic Food Production, Environmental effects of aquaculture, Fish health and water quality, Toxicology

University of Tromsø, UIT

https://uit.no/startsida

Akvamedi (Fish health and medicine biologist), master program, 120 ects (in Norwegian)

- courses: Aquaculture I, Introduction to fish biology, Fysiologi II (dyrefysiologi), Generell mikrobiologi, Havbruksrett, Fish Physiology, Basal and Comparative Immunology, Fiskesykdommer, Fiskeernæring, Oppdrettsteknologi, Fiskepatologi, Matvaretrygghet, Parasittologi og epidemiologi, Farmakologi, Safety in the laboratory and on sea and land expeditions, Aquatic Animal Welfare, Fiskevelferd i havbruk

Bachelor's degree programme in Fisheries and Aquaculture Science, Fiskeri- og havbruksvitenskap, 180 ects (in Norwegian)

- courses: Aquaculture I, Law in fisheries and aquaculture

Master's degree programme in Fisheries and Aquaculture, 120 ects (Fiskeri- og havbruksvitenskap, in Norwegian)

- courses: Marine Industry Development, Seafood production, Fisheries and aquaculture industry in practice, Organizational theory and management, Law in Fisheries and Aquaculture, Field study in Aquaculture, Mathematics for economists, Aquatic ecology, Fisheries chemistry, Fisheries and aquaculture industry in practice, Fish diseases

PhD studies, The Faculty of biosciences, fisheries and economics

Master's degree programme for international students in Fisheries Management, 120 ects

- course: Aquaculture I 10 ects

Master's degree programme in Marine Ecology and Resource Biology, 120 ects

- courses: Aquatic Animal Welfare 10 ects, Aquaculture 10 ects, Advances in Aquaculture 15 ects

University of Stavanger

http://www.uis.no/frontpage/

Master's degree programme in Environmental Engineering, 120 ects

- related courses: Water Chemistry, Natural Water Systems, Environmental Microbiology, Environmental Process Analysis, HSE-course for master students, Interfacial Water Chemistry, Water Treatment and Membranes, Separation Technology, Methods in Water Science and Technology, Offshore Environmental Engineering, Specialisation Water Science and Technology, Aquatic Ecotoxicology, Advanced Organic Chemistry, Operations and Maintenance Management, Engineering Assets, Processes, and Performance, Instrumental Analysis, Biodegradation and Bioremediation, Risk analysis and risk management

1.1.2. Vocational schools

- 13 vocational schools are offering aquaculture education in Norway (in Norwegian)

Nordkapp videregående skole

Måløy vidaregåande skule

Val videregående skole AS

Nord-Troms videregående skole

Senja videregående skole

Strand videregående skole

Fusa vidaregåande skule

Ålesund videregående skole

Fræna vidaregåande skole

Guri Kunna videregående skole Hitra

Austevoll vidaregåande skule

Meløy videregående skole

Sortland videregående skole

1.2. DENMARK

1.2.1. Universities

Technical University of Denmark, DTU
http://www.dtu.dk/english

Master's degree programme in Aquatic Science and Technology, 120 ects also PhD studies in aquaculture section

- courses: Recirculating Aquaculture Systems 5 ects, Marine aquaculture 5 ects, Genetic methods in aquaculture 5ects, Advanced Course in Recirculating Aquaculture Systems: Design and Application 5 ects, Fish Physiology in Aquaculture 5 ects, Applied Marine and Freshwater Ecology 10 ects, Aquatic Ecosystem Management 5 ects, Design of Survey and Monitoring Systems 5 ects, Membrane Technology 5 ects, Chemicals in the environment 10 ects, Fish Nutrition and Bioenergetics 5 ects, Groundwater Resources 10 ects, Water Resources Management 5 ects, Genetic methods in aquaculture 5 ects

Master's degree programme in National Food Institute, 120 ects

- courses: Aquatic Food Primary Production: Fishery and Aquaculture 7,5 ects, Aquatic Food Processing and Technology 7,5 ects, Aquatic Food Supply Chain Management, Environment and Resources 7,5 ects, Safety and Health Effects of Aquatic Food 7,5 ects, Predictive Food Microbiology 5 ects

Master's degree programme in National Veterinary Institute, 120 ects

- course: Diseases and veterinary aspects related to Aquaculture 5 ects

University of Aarhus
http://www.au.dk/en/

Master's and PhD programmes with bioscience - Marine science

- research: cultured Macroalgae

University of Copenhagen
http://www.ku.dk/

Master's degree programme in Biology , 120 ects

- courses: Marine Microbiology and Virology 7,5 ects, Applied Phycology 7,5 ects, Applied Marine Biology (Marin) 7,5 ects, Applied Microbiology 7,5 ects

1.2.2. Vocational school

Hansenberg
https://www.hansenberg.dk/

- offers training in agriculture with a focus on aquaculture

1.2.3. Other training

Centre for Fisheries & Aquaculture Management & Economics
FAME

- a network and research school within resource and fisheries management and economics connecting universities, research institutions and researchers
- supported by the Danish Research Council, NordForsk, University of Copenhagen, Technical University of Denmark and University of Southern Denmark
- the main activities are PhD courses, workshops and seminars

1.2.4. Faroe Islands

At the University of Faroe Islands aquaculture course is taught, but not on regular basis, and this depends on the number of students. There is no separate education on RAS.

1.3. FINLAND

1.3.1. Universities

University of Jyväskylä

www.jyu.fi

Master's degree programme in Aquatic science, 120 ects

- courses: Aquaculture Book Examination 5 ects, Aquaculture 5 ects, Aquatic parasitology 2 ects, Fish bacterial diseases and parasites - practice 3 ects, Fish Processing Book Examination 5 ects
- "The course for the protection of animals used for scientific purposes" gives the competence to carry out procedures with animals (including fishes), and to design procedures and projects (Directive 2010/63/EU: Article 23)
- research from fish parasites and bacterial diseases
- students can get specialization in aquaculture through theses (bachelor and master) as well as work training (internship)
- general issues about aquaculture are taught also within other courses of aquatic science
- a special course on RAS for undergraduate and graduate students within the summer school in 2018 and 2020 https://www.jyu.fi/en/research/summer-and-winter-schools/jss

Åbo Akademi University

https://www.abo.fi/?lang=fi

The Laboratory of Aquatic Pathobiology

- research on infectious diseases in wild and farmed fish in brackish and fresh water

University of Helsinki

https://www.helsinki.fi/

Faculty of Biological and Environmental Sciences

Master's degree programme in Ecology and Evolutionary biology, 120 ects

- courses: book examinations from aquaculture and fish processing
- students can get specialization in aquaculture through theses (bachelor and master) as well as work training (internship)
- general issues about aquaculture are taught also within other courses of aquatic science

Faculty of Veterinary Medicine

Bachelor's degree programme in Veterinary Medicine

The profession of a Veterinarian degree programme in Veterinary Medicine

- 6 hours of fish diseases with a brief introduction to fish farming and diseases of cultured fish
- 1h of slaughter, meat inspection and food processing (safety and shelf life)

- the first course on Fish health in aquaculture was organized in early 2017 (available every second year)

1.3.2. Vocational schools

Livia College, the College of Fisheries and Environment

http://livia.fi/en

Vocational degree in fish farming (in Finnish)

Salpaus Further Education

https://en.salpaus.fi/

Vocational degree in fish farming (in Finnish)

Vocational school Lappia

http://www.lappia.fi/

Adult education for Fish farmer's vocational degree (in Finnish)

1.4. SWEDEN

1.4.1. Universities

University of Gothenburg, GU

http://www.gu.se/

Master's degree programme in Biology, 120 ects

- courses: Comparative Physiology of Marine Animals including Applications for Aquaculture 15 ects, Aquaculture, Animal ecophysiology from a climate perspective 15 ects, Stream Ecology and Fish Conservation 15 ects, Marine Biodiversity 15 ects, Conservation ecology in water environments 15 ects, An introduction to ecophysiology - plants and animals 7,5 ects, Ecological Toxicology: Ecology 15 ects, Ecological Toxicology: Physiology 15 ects, Experimental marine ecology 15 ects, Primary Producers of the Sea 15 ects, Sustainable development: A case study approach 15 ects, Applied environmental law 15 ects, Environmental management systems 15 ects, Resource efficiency - energy, material flows and ecosystem services 15 ects, Advanced Environmental Methodology 15 ects

Master's degree in Marine sciences 120 ects

- courses: Marine project - From idea to action 15 ects, Biogeochemical cycles in the sea 15 ects, Chemical Dynamics in the Sea, Changes in the Oceans, historical trends and antropogenic influence 15 ects
- all listed courses are available for both programmes

SWEMARC, research center of the Gothenburg University's

- Organize aquaculture courses and meetings
- Master and PhD projects in sustainable Aquaculture
- Coordinates a new Nordic master program just granted funding for development with start fall semester 2019:

Nordic master progamme in Sustainable Production of Marine Bioresources, MAR-BIO, 120 ects

a Nordic collaborative transdisciplinary programme where courses listed above can be included plus: Corporate Social Responsibility in Event and Tourism 15 ects, Planning and Design for Sustainable Development in a Local Context 22,5 ects, Maritime Environmental Law 15 ects, European Marine Directives and Policies – an Interdisciplinary Perspective 15 ects, and new courses developed for a second new Masters programme: ***Master in Sea and Society Science 120 ects,*** see below

Center for Sea and Society at University of Gothenburg, hosts

Graduate school in marine environmental research, PhD

- The multidisciplinary graduate school in environmental marine research

Master in Sea and Society Science, 120 ects, under development, planned start fall 2019, in addition to part of the courses listed above three new courses are under planning: MARXX1. The sea and society relationship; historical perspectives, present status and future challenges, MARXX2. Bluegreen economy and sustainable use of marine resources, MARXX4. The spatial dimensions of marine ecosystems and their governance

Summer school

- course: Aquaculture, basic

Swedish University of Agricultural Sciences, Sveriges lantbruksuniversitet, SLU
https://www.slu.se/

SLU UPPSALA

Faculty of Veterinary Medicine and Animal Science / Collaboration at the VH-faculty

- competence areas within aquaculture science include: Sustainable feeds, Nutrition and metabolism, Environmental effects of fish farming, Breeding and reproduction, Production systems, Fish health and welfare, Fish diseases and Fish quality

Master's degree programme of animal sciences, 120 ects

SLU SKARA

Master's degree programme in Ethology and Animal Welfare, 120 ects

- teaching for animal health and that includes fish welfare

SLU ALNARP

- research on aquaponics

Nationellt kompetenscentrum för vattenbruk, NKfV
http://nkfv.se/

- strategic cooperation body for long-term national development of aquaculture with a focus on knowledge-based information and communication
- the site is created by **Swedish University of Agricultural Sciences (SLU)** and **Gothenburg University (GU)**

KTH Royal Institute of Technology
https://www.kth.se/en

Master's programme in Environmental Engineering

- no aquaculture courses
- related courses: Water and Wastewater Handling 7,5 ects

1.4.2. Vocational schools

Lysekil University College

http://www.lysekil.se/gullmarsgymnasiet.html

Marine natural resources program (in Swedish)

- courses: Vattenbruk, grunder 100 p, Vattenbruk, specialisering 100 p

Adult education (one year): Fish and shellfish farmers

Naturbruksgymnasiet, Osby

http://www.naturbruksgymnasietosby.se/

Fish tourism and aquaculture, 2600 points

- courses: Aquaculture - Basics 100 p, Fish farming 1, 200 p, Fish farming 2, 200 p, aquaculture - specialization 100 p

1.5. ICELAND

1.5.1. Universities

Háskólinn á Hólum, Hólar University College

http://www.holar.is/en/english

Aquaculture, Diploma, 90 ects

- courses: Fish and Water 6 ects, Introduction to Aquaculture 8 ects, Fish Reproduction 6 ects, Larvae Culture 6 ects, Health and hygiene 4 ects, Harvest and Processing 6 ects, Environmental Issues of Aquaculture 6 ects

Master's and PhD degree programmes in Aquatic Biology

- courses: Development of Aquaculture 12 ects

University Centre of the Westfjords

http://www.uw.is/

Master's degree programme in Coastal and Marine Management, 120 ects

- course: Sustainable Aquaculture 4 ects

University of Akureyri

Diploma and Master's degree programme in Aquatic and Marine Biology

- courses: Marine-based food innovation, Fish farming I, Fish as food

Bachelor degree programme of Fisheries Science, 180 ects

- courses: Marine-based food innovation, Fish farming I, Fish as food

University of Iceland HI, UoI

http://english.hi.is/

Engineering and Natural Sciences Faculty of Life and Environmental Sciences

Bachelor's degree programme in Aquatic and Marine Biology, 180 ects

Bachelor's degree programme in Biology, 180 ects

Master's degree programme in Biology, 120 ects

- no aquaculture courses
- related courses: Fish Biology, Aquatic and Fisheries Sciences, Environmental Microbiology, Virology, Immunology etc.

1.5.2. Vocational schools

Icelandic College of Fisheries, Fisktækniskóla Íslands
https://www.fiskt.is/

1 year programme from aquaculture (in Icelandic)

- courses: Fish diseases and health, Biology of fish and aquaculture, Information technology for aquaculture, Hatchery, Pumps, Feeding, slaughter, hydrology etc.

1.6. AQFood - Aquatic food production - Safety & Quality

The international Master's degree programme "Aquatic Food Production – Safety and Quality" (AQFood)

The collaboration of five universities:

- Technical University of Denmark (DTU), National Food Institute, Kgs. Lyngby, Denmark
- Norwegian University of Science and Technology (NTNU), Department of Biotechnology, Trondheim, Norway
- Norwegian University of Life Science (NMBU), Department of Mathematical Sciences and Technology, Aas, Norway
- Swedish University of Agricultural Sciences (SLU), Department of Wildlife, Fish and Environmental studies, Umeå, Sweden
- University of Iceland HI (UoI), School of Engineering & Natural Sciences, Reykjavik, Iceland

Study tracks: Aquatic production, Industrial production, Natural resources

- courses: Fishery and Aquaculture 7,5 ects, Aquatic Food Processing and Technology 7,5 ects, Safety and Health Effects of Aquatic Food 7,5 ects, Aquatic Food Supply Chain Management 7,5 ects, Environment and Resources 7,5 ects, Basic Aquaculture Engineering 5 ects, Aquaculture Production 10 ects, International Aquaculture Laboratory Course 5 ects, Aquatic Production and Fish Wild Life Management: Fish and Wildlife Census Techniques 15 ects, Project based advanced course 15 ects, Introduction to food production chains 10 ects, Predictive Food Microbiology 5 ects

2. RAS-meeting discussion

"Nordic Road Map for Blue Bioeconomy"- meeting in Finland 28.-29.11.2017.

Discussion regarding aquaculture, especially RAS, education in different Nordic countries

The following country-wise discussion is mainly based on the following questions:

- Is aquaculture and especially RAS related teaching given within other curricula such as veterinary education or civil engineering?
- Do governmental research institute personnel participate in aquaculture/RAS teaching in universities and schools? Is it part of work or extra/voluntary?
- To develop RAS sector and its R&D, is there any need to increase and emphasize RAS issues in curricula?
- Are there frequent summer schools on RAS issues?
- Do universities and schools have their own RAS research facilities?
- Are there any courses or curricula for employees of aquaculture companies?
- Is it easy to get students for the sector?
- Any other issues

2.1. NORWAY

In NTNU there is a master level course on RAS (7,5 ects). There are no practical parts on this course.

No summer schools are offered.

In Trondheim (NTNU) there are 4 RAS units to be used, and the students have the right to use these units in the first place.

At NMBU all aquaculture training takes place in RAS.

In Norway academic research personnel are expected to give teaching. In Trondheim there is further education course in Aquaculture which includes seminar for 3-4 days. This is aimed at workers within the industry.

In Norway aquaculture is currently an attractive discipline for students while studies related to oil industry are becoming less attractive. As such there are no problems in getting motivated students.

There is a booklet named "Recycling of water in hatchery production" which can be ordered by e-mail from Henny.Jokiel.Knudsen@niva.no (an English version also available).

2.2. DENMARK

At DTU Copenhagen there are currently 2 RAS courses, and one more is under development. In the University campus in Copenhagen there is a small RAS test system while bigger system is in use in Hirtshals.

In DTU all researchers give teaching, depending on the position, 20-50% of working hours.

A common practice is to have collaboration between biologists and engineers, and training on both directions. For engineers there are currently no specific courses on aquaculture nor RAS.

Researchers from governmental institutes are expected to contribute to teaching for free.

The Advanced RAS course at DTU (5 ects) is a summer course and it attracts also international students. The course size is 10-12 students. At DTU there is a plan to put all aquaculture courses for the spring semester so it would be easy especially for visiting students to specialize in aquaculture.

There are not really any further education courses available. However, there is an interactive e-book available in Danish.

In general, it is not easy to get students, but on the other hand, this is not promoted or advertised in any manner.

2.3. FINLAND

Whether or not the researchers give teaching depends on the possible agreements between the universities and research institutes. For example, researchers from Natural Resources Institute Luke can give a maximum of 4 h of teaching per year without compensation by the University of Jyväskylä. However, teaching for institute researchers is not obligatory.

Currently in Finland, the only branch of aquaculture that get new permits in the continental area is RAS. Bearing that in mind there would be apparent need for training specialists to work especially in RAS. A RAS summer school will be organized in the University of Jyväskylä in summers 2018 and 2020.

Both Livia College and University of Jyväskylä have small RAS units. The proximity of Luke Laukaa RAS research facility gives excellent possibility for University of Jyväskylä students to do their theses about RAS. However, aquaculture does not seem to be attractive for students and it is difficult to get trainees, or students to commit to working on aquaculture related topics.

There are no specially organized courses for employees of aquaculture companies.

2.4. SWEDEN

SLU: in Umeå there is no more aquaculture related teaching or research while Uppsala is the main campus for aquaculture teaching and research. Even if there are no specific aquaculture courses, fishes are included as a part in all courses. There is also collaboration with the department of chemistry, especially regarding water quality. In SLU Skara there is teaching for animal health and that includes fish welfare. In SLU Alnarp campus there is aquaponics (do they have teaching regarding aquaponics?). In general, at SLU there are no plans to start giving teaching for RAS.

The University of Gothenburg together with the Swedish Mariculture Research Center has organized PhD courses (one in 2015 and 2017) related to aquaculture but not directly to RAS. Within the normal master courses the University of Gothenburg there is only one lecture regarding RAS.

In Sweden RAS is only in use when tropical fishes are farmed.

In Gothenburg there is a basic aquaculture summer school course.

The universities where aquaculture teaching is given do have small RAS units.

There is no further education of aquaculture for employees within the sector.

The vocational aquaculture schools in Sweden are actually over-applied but there is a big loss (c. 50%) of students during the studies, mainly due to working at the same time. There seem to be interest in aquaponics-type culture methods, and if this education were available it would possibly attract students. However, for the industry sector it seems to be difficult to attract people. Thus, there is apparent need for introductory courses in aquaculture.

2.5. ICELAND

So far there has been very little interest in aquaculture related education, but at the moment aquaculture is increasing and thus there is more interest in aquaculture, and there is apparent need to change the curricula in this respect. All courses in the Holar University College are distance education.

Teaching by the researchers from the research institutes comes mainly in the form of collaboration, and teaching is included as a part of the projects.

There is apparent need to increase RAS education, using e.g. distance education. Such courses can last e.g. 3 weeks and the students need to come for practical sessions for 3 days.

There are no summer courses. In the spring 2018 there will be an intensive 3-day RAS course with invited teacher coming from the USA, and the course is paid by the industry.

At the Holar university there is a small RAS but it is not running at the moment.

There is apparent need for further education for the people within the aquaculture sector.

Regarding attractiveness for students, it is not easy to get them. Currently all PhD students are foreigners.

2.6. General issues regarding education of aquaculture, especially RAS:

Based on the meeting discussions there appears a clear need for collaboration within the Nordic countries in terms of RAS education. However, the meeting participants did not make any conclusion on how to proceed in this respect. Some suggestions were made, such as a course split between the Nordic universities so that the students would not need to travel but they would be connected by video to teaching sessions in each university. It was also suggested that it would be practical and useful to have both industry people and students together on a same course.

All information regarding aquaculture training should be available on one website, for example on the Nordic network on RAS http://www.nordicras.net.