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Welfare of farmed fish: Common practices during transport and at slaughter

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Directorate-General for Health and Food Safety

European Union Strategy for the Protection and Welfare of Animals 2012-2015

2017

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EXECUTIVE SUMMARY

Introduction

The aim of this study was to gather information on current animal welfare practices in European aquaculture as regards the transport and slaughter of farmed fish, and to analyse the extent that fish welfare issues remain unresolved. The costs of adhering to good welfare practices, the economic situation, effects on competitiveness and other factors were taken into account. The reference period was 2009-2013.

The study focused on the five main farmed fish species to provide a general presentation of the current situation in European aquaculture: Atlantic salmon (cold-water marine); common carp and rainbow trout (freshwater), and; European sea bass and gilthead sea bream (Mediterranean marine).

The international standards of the World Organisation for Animal Health (OIE) on animal welfare during transport and stunning and killing of farmed fish for human consumption were used as a benchmark for assessment of welfare practices. EFSA recommendations on slaughter were also taken into account.

Review of current fish welfare practices

The main methods of transporting live fish in the EU are by road and sea (well-boat). Transportation methods were reviewed for two stages of production: transport of fry, fingerlings or juvenile fish to on-growing facilities (for Atlantic salmon, European sea bass and gilthead sea bream), and; transport of marketable fish for slaughter (for Atlantic salmon, common carp and rainbow trout). It was agreed that the study would not assess transport for on-growing for common carp and rainbow trout; and it is not relevant for marketable sea bream and sea bass as these species are slaughtered on-farm without transport between facilities.

Impaired welfare and stress during transport may be caused by many factors including changes in stocking density, handling, water movement and poor water quality. Different fish species have different requirements regarding oxygen, pH, salinity and temperature, and they have different abilities to cope with variances of these parameters.

Slaughter activities include handling, restraining, stunning and killing. Stunning should cause loss of consciousness and sensibility without avoidable stress, discomfort or pain. In some methods, it may also cause death. When the stunning method is reversible or does not cause death, it should be followed by a killing method. The OIE advises the use of electrical or mechanical stunning and killing methods, although these have not yet been developed or applied in practice for all fish species. Other stunning and killing methods – such as live chilling followed by electrical stunning, live chilling with carbon dioxide (CO_2), carbon dioxide stunning, and asphyxia in ice – are considered to result in poor fish welfare and do not meet OIE standards.

The most common methods for slaughtering Atlantic salmon are percussion, and electrical stunning followed by a killing method. In most cases Atlantic salmon are removed from water before electrical stunning, which may however be more stressful than electrical stunning in water, as the fish are exposed to air. Live chilling with CO_2 is used to a limited extent in Norway. In Ireland, CO_2 stunning is still used to a limited extent, although its use is declining.

Common carp are stunned and killed by a manual blow to the head, with a period of prior exposure to air. Exposure to air for 10 minutes, as is common practice, is stressful. Electrical stunning in water is also used. For rainbow trout, electrical stunning and asphyxia in ice are the most common methods, although manual percussion, CO_2 stunning, and chilling in ice slurry followed by electrical stunning are also used to a limited extent in France. Asphyxia in ice is still the most common slaughter method for European sea bass and gilthead sea bream; electrical stunning is still in an experimental stage in Greece for these species.

The impact of improved animal welfare practices on product quality is complex, because the effects may vary between welfare practices and between the fish species under consideration. Improved welfare practices such as percussion and electrical stunning can lead to carcass damage, but this can be avoided or minimised by drawing up specifications to ensure little or no detriment to product quality. As fish welfare becomes more widely acknowledged as a factor in product quality, it can be expected that more attention will be given to identifying practices that improve both welfare and product quality.

OIE and national standards on farmed fish welfare

The study found that OIE standards are likely to be achieved with regard to the transport of smolts and marketable Atlantic salmon, marketable rainbow trout, and fry/fingerling/juvenile European sea bass and gilthead sea bream in the case-study countries. It was found that transport of marketable common carp for slaughter in Poland and Germany only partly meets OIE standards, although it does meet Council Regulation 1/2005. In the Czech Republic, transport of common carp for slaughter meets OIE standards.

The achievement of OIE standards at slaughter was found to depend on the species. In Norway, the UK and Ireland the standards are met for percussion of Atlantic salmon. In Norway 25-30 % of fish are oriented (i.e. they are positioned so they enter the stunner head-first) prior to electrical stunning after dewatering, though this percentage is increasing. With orientation, the OIE standards are met for electrical stunning after dewatering. However, electrical stunning should be followed by decapitation or percussion as a killing method to meet OIE standards. Live chilling with CO2 is still used in Norway to a limited extent. This method, which will be phased out, does not meet OIE standards. Carbon dioxide levels for live chilling with CO2 are substantially lower than used for CO2 stunning. In Ireland, CO2 stunning is still used to a limited extent, although its use is declining. Carbon dioxide stunning does not meet OIE standards.

For common carp, the achievement of OIE standards for electrical stunning in Poland, the Czech Republic and Germany depends on the construction of the equipment. Information about the construction is scarce. Manual percussion (a blow to the head) is common practice in Poland and Germany and, when applied correctly and instantaneously after exposure to air, meets OIE standards.

Similarly, the achievement of OIE standards for electrical stunning of freshwater rainbow trout in Denmark and Italy depends on the design and construction of the equipment. Asphyxia in ice is still practised on about 30 % of production in Denmark. In Poland asphyxia in ice is also used. Manual percussion of trout in France meets OIE standards provided it is performed instantaneously after exposure of the fish to air. However, in France both CO_2 stunning and chilling in ice water followed by electrical stunning do not meet OIE standards.

Asphyxia in ice of sea bass and sea bream is still practised in Greece, Spain and Italy. OIE standards at slaughter are therefore not achieved for these species.

National legislation and guidelines are not as well developed in the EEA states as for terrestrial farm animals, although the situation is improving due to growing attention on fish welfare. For the five species covered by the study, private standards that include welfare during transport and slaughter are predominately implemented in the salmon sector, to a lesser extent for trout, and on a limited scale for sea bass and sea bream. A very limited number of carp farms are covered by private welfare standards.

Socio-economic aspects

EU aquaculture can be classified into four main types according to environment and species: shellfish, with a production of 653 000 tonnes in 2010; freshwater species (332 000 tonnes); Mediterranean marine species (213 000 tonnes), and; cold-water marine species (190 000 tonnes). The total production volume of 1 388 000 tonnes in 2010 is forecast to grow by 56 % to 2 161 000 tonnes in 2030[1].

[1] European Parliament, The long-term economic and ecologic impact of larger sustainable aquaculture (2014)

The study focused on five finfish species and did not address shellfish.

The key investment to achieve good welfare practices in the EEA states for fish during transport was identified as water quality equipment. As the use of this equipment is already widespread, no further investments are required to meet OIE standards during transport, and transport was not considered further in the economic analysis.

It should be noted that the economic aspects associated with specific welfare practices are based on limited available data from a specific reference period, 2009-2013. While the analysis gives an indication of costs and prices at the time of survey, it may not reflect trends over a longer period, or over the period since. Wider extrapolation to other years, volumes and species should not be considered on the basis of the data in this study alone.

Atlantic salmon – The top five world salmon producers are Norway (56 % of world production in 2013), Chile (24 %), United Kingdom (8 %), Canada (5 %) and the Faroe Islands (4%). Ireland produces 0.4%. Production in Norway increased by 35 % between 2009 and 2013. In the United Kingdom it increased by 13 % and in Ireland it decreased by 25 % over the reference period.

The STECF[2] database indicated substantial differences in efficiency between the EEA states: in 2012, the cost price of Atlantic salmon in Norway, the United Kingdom and Ireland was calculated to be 2.66, 3.19 and 6.34 euros/kg respectively. Sales prices also varied substantially between the states. In Ireland in 2012 the cost price was higher than the sales price; this can be attributed to the average enterprise in Ireland being relatively small with relatively more employees and higher value of assets. It should be noted that the economic performance of the sector is likely to have evolved since the reference period.

Two methods to improve the welfare of salmon at slaughter were considered: 1) electrical stunning before dewatering, and; 2) stunning by percussion after dewatering. The annual costs of these investments – taking into account labour savings – are about 2 euro cents/kg or 0.5 % of the sales price in UK, and no more than 9 euro cents/kg or less than 1.5 % of the sales price in Ireland. Large-scale producers, as in Norway, would even see a net reduction in the unit production cost of about one euro cent/kg of fish as the labour savings outweigh the investment costs.

As there is already a high level of implementation of fish welfare practices in the salmon industry in EEA states, relatively few enterprises will need to invest to meet OIE standards. Small-scale producers will benefit less from economies of scale, unless they share facilities with other producers. The impact on competitiveness will therefore be small for Norway and the United Kingdom. A substantial part of the Irish production is exported at premium prices (organic production); therefore the effect on international competitiveness is likely to be small.

Common carp – Poland, the Czech Republic, Hungary and Germany together produced 1.3 % of world carp volume in 2013. Whilst world production, dominated by China, grew 26 % between 2009 and 2013, production in the four EEA states declined by 8 %.

Without subsidies, carp farming was generally not a profitable activity in the EEA between 2009 and 2013. This holds true between countries despite large variations in production costs. In 2012, the production cost in Germany, Poland and Romania (the countries where the most reliable data were available) was 3.38, 2.08 and 1.31 euros/kg respectively. The main factors contributing to this variation are differences in production volume. In all three countries, the cost price exceeded the sales price (excluding subsidies and other income). Poland is a larger volume producer, but does not appear to benefit from economies of scale. EEA production costs are approximately double those in China.

[2] The principal data sources used in the study include the Scientific, Technical, and Economic Committee for Fisheries (STECF), Eurostat, Food and Agriculture Organisation (FAO) Global Fishery and Aquaculture Statistics, and the Federation of European Aquaculture Producers (FEAP).

The methods that were considered to improve the welfare of common carp at slaughter in line with OIE standards were electrical stunning – either before or after dewatering – followed by decapitation. Electrical stunning after dewatering is more expensive with 17 % higher annual costs.

The additional unit cost of production varied significantly according to the scale of the enterprises. For the cheaper of the two methods – electrical stunning before dewatering – the extra cost was 6 euro cents/kg in Poland, 41 euro cents/kg in Romania, and 58 euro cents/kg in Germany. As a percentage of the sales price, the figures were 2.8 %, 24.4 % and 24.0% respectively.

Investment to improve welfare at slaughter would be difficult for enterprises that are already unprofitable, although collaboration between small-scale producers would give economies of scale. Most farmed carp (98 % in 2012-2013) is consumed in the country of production and therefore the effect of improved welfare practices on international competitiveness will be limited. In Europe, sales prices in domestic markets are higher than those for export.

Rainbow trout – The major EEA producers – Norway, Italy, Denmark, France and Poland – account for 22 % of world production of rainbow trout. Chile is the largest producer and the largest exporter, although its output has fallen markedly since 2012. After Chile with a 31 % share of exports, six EEA States make up the top seven exporters: Norway (26 %), Denmark (8.5 %), Italy (3.7 %), Sweden (3.7 %), Spain (3.3 %) and France (2.7 %). China and the Russian Federation are major producers, but not major exporters.

Trout farms in Italy, Denmark and France show a varying picture regarding profitability. Italy has the largest enterprises, followed by Denmark and France. Italian farms also had the lowest unit cost of production at 1.90 euros/kg in 2012 and were profitable without subsidies. Unit production costs in Denmark and France were higher at 2.9 and 3.1 euros/kg, and both were, on average, unprofitable without subsidies. It should be noted that the economic performance of the sector is likely to have evolved since the reference period Insufficient economic data was available for analysis of trout farming in Poland.

Chile has a considerably higher production cost than the EEA states, and the cost price per kg exceeds the export price, making it difficult for Chile to compete in the export market.

OIE standards at slaughter for trout are only partly achieved and further investment in the slaughter process is required to meet them, particularly in Denmark and France. One method was considered: electrical stunning before dewatering , followed by manual gill cutting. This investment results in labour savings and therefore particularly benefits large-scale producers and those with high salary levels.

Investment in electrical stunning before dewatering on Italian trout farms was calculated to reduce production cost by 6 euro cents/kg as a result of labour savings. In Denmark and France, there was an additional cost of 4 euro cents/kg and 24 euro cents/kg respectively.

The cost of implementing improved welfare at slaughter for trout is relatively small for large-scale producers and may even result in cost savings. In contrast, the cost for small-scale producers, as in France where CO_2 is still used as a stunning method, is notably high – up to 30 euro cents/kg. Sharing of facilities by enterprises to achieve economies of scale would help to mitigate the extra costs.

European sea bass and gilthead sea bream – Four countries accounted for 85 % of world production of European sea bass in 2013: Turkey (46 %), Greece (24 %), Spain (10 %) and Italy (5 %). The same four countries accounted for 75 % of world production of gilthead sea bream: Greece (36 %), Turkey (23 %), Spain (12 %) and Italy (3.4 %). About 50 % of world production of both species is exported (including re-export).

The finances of sea bass and sea bream aquaculture were analysed together in each of the three case study countries (Greece, Spain and Italy) as information sources provide composite data.

The production of sea bass and sea bream was generally not profitable in Greece, Spain and Italy over the reference period (2009-2013) and only survived with subsidies and other sources of income.

The unit production cost in these states varied between 5.36 and 6.71 euros/kg over the period. Spain has the largest enterprises, followed by Greece and Italy. However, Spanish enterprises have relatively high numbers of employees and therefore no economies of scale were evident. It should be noted that the economic performance of the sector is likely to have evolved since the reference period

The overall sales price in the EEA states varied around 5.50 euros/kg. The export price was lower at roughly 4.50 euros/kg. In Turkey – the main competitor country – the sales and export prices were lower at around 3.80 and 3.60 euros/kg respectively.

Two methods to improve fish welfare at slaughter in order to meet OIE standards were considered: 1) electrical stunning before dewatering, and; 2) electrical stunning after dewatering, both followed by chilling in a slurry of ice and sea water. Electrical stunning before dewatering is the more expensive option with 25 % higher annual costs.

The additional unit cost varies slightly between the methods, but it varies to a greater extent between countries according to the size of enterprises. In Spain – with the largest enterprises – the additional unit cost was 4 euro cents/kg for both methods. In Greece, it was 5-6 euro cents/kg depending on the method, and in Italy – with the smallest enterprises – it was 11-13 euro cents/kg. As a percentage of the sales price, the additional cost was 0.6-0.7 % in Spain, 0.9-1.1 % in Greece and 1.5-1.9 % in Italy.

Although the extra costs are relatively modest as a proportion of the sales price, they may cause difficulties for enterprises that are already unprofitable without subsidies. There is a considerable variation in profitability between producers, mainly related to the scale of production.

Conclusions

OIE standards for transport are largely achieved in the case-study countries for Atlantic salmon, rainbow trout, European sea bass and gilthead sea bream. Some shortcomings were identified regarding the transport of common carp for slaughter.

The level of achievement of OIE standards at slaughter varies with the species. For Atlantic salmon, best practices are mostly achieved, with a few exceptions. For common carp and rainbow trout, the level of achievement varies between methods used. For European sea bass and gilthead sea bream, OIE standards are not achieved.

The economic analysis shows that differences in production cost are mainly caused by the structure of the industry, with particular benefits from economies of scale. Improving welfare practices is likely to have only a very small impact on the cost price. Other factors, such as feed, labour and operating costs are responsible for larger variations between enterprises and countries. The effect of implementing improved welfare practices is greatest on smaller farms.

On salmon and trout farms, investment in improving welfare leads to labour savings and may outweigh the investment cost on larger farms.

Carp is mainly consumed in the country of production and was generally not profitable without subsidies between 2009 and 2013 in typical EEA production systems. Small farms are likely to have most difficulty in investing to improve animal welfare and may experience a competitive disadvantage. However, the export position of the country is unlikely to be affected.

Production of sea bass and sea bream was generally not profitable between 2009 and 2013 without subsidies in the major EEA states. It should be noted that the economic performance of the sector is likely to have evolved since the reference period It may therefore be difficult for producers to make the necessary investment to improve welfare standards. Turkey has been increasing production and exports, but lower export value indicates that Turkey is unable to achieve the same market prices as the EEA States.

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ABBREVIATIONS

AAH	Aquatic Animal Health
AC	Autonomous Community
AHAW	EFSA Panel on Animal Health and Welfare
ASC	Aquaculture Stewardship Council
BAP	Best Aquaculture Practices
BBFAW	Business Benchmark on Farm Animal Welfare
CA	Competent Authority
CCRF	Code of Conduct for Responsible Fisheries (FAO)
CEFAS	Centre for Environment, Fisheries and Aquaculture Science (UK)
CIWF	Compassion in World Farming
CoGP	Code of Good Practice for Scottish Finfish Aquaculture
EAS	European Aquaculture Society
DEFRA	Department of Environment, Food and Rural Affairs
DG	Directorate General
DG SANTE	Directorate General for Health and Food Safety
ECG	Electrocardiogram
EEA	European Economic Area
EEA States	EU Member States (28) and EEA EFTA States (3)
EEG	Electroencephalogram
EFSA	European Food Safety Authority
EFTA	European Free Trade Association
EU	European Union
EUREP	EuroRetailer Produce Working Group
FADN	Farm Accountancy Data Network
FAO	Food and Agriculture Organisation
FEAP	Federation of European Aquaculture Producers
FTE	Full-time employment
FVO	Food and Veterinary Office (now DG SANTE, Directorate F, Health and Food Audits and Analysis - HFAA)
GAA	Global Aquaculture Alliance
GSSI	Global Sustainability Seafood Initiative
HOG	Head on gutted
HSA	Humane Slaughter Association
IDH	Dutch Sustainable Trade Initiative
kg	Kilogramme
NA	Not available
NGO	Non-governmental organisation
OIE	The World Organisation for Animal Health
RAS	Recirculation Aquaculture Systems
RSPCA	Royal Society for the Prevention of Cruelty to Animals
RTA	Relative Trade Advantage
SME	Small and Medium-sized Enterprise
spp	Species
STECF	Scientific, Technical and Economic Committee for Fisheries
TAN	Total ammonia nitrogen
UK	United Kingdom
UN	United Nations

USD	United States Dollar
VER / VEP	Visually evoked response (VER) / visually evoked potential (VEP)
WAP	World Animal Protection
WAS	World Aquaculture Society
WUR	Wageningen University & Research Centre
WWF	World Wildlife Fund

1. INTRODUCTION AND BACKGROUND

1.1. INTRODUCTION

The IBF Consortium, including the IBF Consumer Policy Centre, VetEffecT and Wageningen University & Research Centre (WUR) was awarded the contract for the study on "Welfare of farmed fish: Common practices during transport and slaughter"[3]. The contract started on 13 September 2016 for a period of 12 months.

1.2. OBJECTIVES OF THE STUDY

1.2.1. AIM

As stated in the terms of reference: "*The aim of the study is to gather information on current animal welfare practices prevailing in European aquaculture as regards the transport and slaughter of farmed fish. Information will also be gathered on national rules and on the use of international standards, best practices or voluntary assurance schemes. The data collected will be analysed to illustrate to what extent fish welfare issues are addressed or remain unresolved. In addition, factors which may influence the use of animal welfare principles such as the economic situation of the aquaculture industry, trade issues and available knowledge among business operators will be assessed.*"

1.2.2. SPECIFIC OBJECTIVES

1. Review the state of play regarding the welfare of farmed fish during transport and at the time of killing under current practices in Europe, using international standards as a benchmark.,
2. Collect information on socio-economic aspects of the aquaculture sector and assess the costs and benefits of adhering to good animal welfare practices[4].
3. Describe and evaluate factors that promote, restrict or prevent the use of humane transport[5], handling, stunning and killing methods by the sector, such as the availability of commercial equipment, knowledge base, trade and the distribution of small and medium-sized enterprises (SMEs).
4. Determine any positive and negative effects that the addressing of animal welfare issues may have on the competitiveness of enterprises.

1.2.3. EXPECTED RESULTS

The expected results from undertaking the four tasks to meet the specific objectives and the aim are:

[3] SANTE/2016/G2/SI2.736160

[4] Existing benefits, e.g. better fish meat quality due to fish that are not stressed at time of killing or existing competitive advantages for the image of the final product resulting in premium prices are addressed. Potential benefits of improved welfare will not be addressed.

[5] Note that humane transport of fish implies optimal transport with regard to fish welfare.

Aim

To gather information on current animal welfare practices prevailing in European aquaculture as regards the transport and slaughter of farmed fish

Result 1
- Description of current practices in European aquaculture regarding the welfare of farmed fish during transport and at time of killing

Result 2
- Analysis of the socio-economic aspects of the European aquaculture sector and the cost of adhering to good animal welfare practices during transport and slaughter

Result 3
- Analysis of factors that promote, restrict or prevent the use of humane transport, handling, stunning and killing methods by the sector

Result 4
- Appraisal of the effect of differences in animal welfare standards on the competitiveness of enterprises in the European aquaculture sector on the global market

1.2.4. PROJECT STAKEHOLDERS

The main stakeholders for the study are shown in Table 1.

Table 1. Project stakeholders

Stakeholders	Role in the project
DG SANTE	Contracting authority for the study
Competent authorities in EEA States[6]	Key stakeholder to assess adherence of farmed fish operators with EU and national legislation
EEA fish producers, equipment manufacturers and their representative organisations	Key beneficiary of the study, and primary target for the analyses
Animal welfare organisation both at EU, EEA and national level.	Important organisation representing citizens involved in farmed fish welfare
Consumer organisations	Ultimate key client of the farmed fish products

[6] 28 EU Member States (28) and 3 EEA EFTA States: Norway, Iceland, Liechtenstein

1.3. IMPORTANCE OF AQUACULTURE IN THE EEA

1.3.1. IMPORTANCE OF AQUACULTURE

Aquaculture will have an increasing role in feeding an increasing global population. The contribution from aquaculture to the world total fish production of capture and aquaculture in 2012 reached 42.2 %, up from 25.7 % in 2000[7]. Aquaculture production is highly concentrated in the Asia–Pacific region, which accounts for an estimated 90 % of global production. According to FAO statistics, China alone accounted for 62 % of the world's aquaculture production in 2013. Asia accounted for 92 % of world aquaculture finfish production by volume in 2010, whereas for Europe this was 5.2 %. The scale of the global aquaculture industry is likely to double in a decade.

Currently in the EU, aquaculture accounts for about 20 % of total fish production. The sector is mainly composed of SMEs or micro-enterprises in coastal and rural areas. EU aquaculture is renowned for its high quality, importance given to sustainability, and attention to consumer protection standards.

1.3.2. SIZE OF THE INDUSTRY AND EXPECTED GROWTH

European aquaculture is very diverse, not just in terms of species, but also in the technologies that are used. Aquaculture can be classified according to various primary characteristics, such as scale, intensity of production and feeds used, and finally by a matrix of environment and/or species (or species group). While EU aquaculture (in terms of numbers of producers) is dominated by microenterprises and family firms, the marine cold- and warm-water sub-sectors include large multi-national companies. Consolidation and vertical integration is continuing both in the cold-water and Mediterranean sub-sectors.

A study for the EU Parliament[8] gives a description of the main production systems currently in use in the EU and the projected growth of the industry (Table 2):

- For cold-water marine species—mainly Atlantic salmon (*Salmo salar*)—the trend is for production growth of more than 100 % by 2030, equivalent to 4 % per year. The projection is based on solid markets and production moving increasingly to offshore locations.
- Similar growth trends are predicted for Mediterranean marine species—mainly European sea bass (*Dicentrarchus labrax*) and gilthead sea bream (*Sparus aurata*)—with average production growth of 4 % per year.
- Production growth in the freshwater—rainbow trout (*Oncorhynchus mykiss*) and common carp (*Cyprinus carpio*)—sub-sector is estimated to reach 40 % by 2030, or 1.5 % per year. This is considerably less than the other sub-sectors. This growth will be based on diversification (not necessarily to new species). The recognition of environmental services will be important for extensive operations.
- Shellfish production growth is projected to reach 30 % by 2030, equivalent to an annual growth rate of 1.3 %/year. This growth relies on overcoming current levels of mortality (especially in oysters) and the development of breeding programmes and hatcheries for the key species.[9]

[7] ftp://ftp.fao.org/fi/stat/Overviews/AquacultureStatistics2012.pdf
[8] http://www.europarl.europa.eu/RegData/etudes/STUD/2014/529084/IPOL_STU%282014%29529084_EN.pdf
[9] Note that shellfish are not part of this study.

Table 2. Forecast growth of the EU aquaculture industry for the period 2010-2031*

	Production (tonnes)		Value (million euros)		Employment (persons)	
	2010	**2030**	**2010**	**2030**	**2010**	**2030**
Cold-water marine	190 322	382 016	572	1 160	2 139	2 865
Freshwater	331 868	476 068	869	1 356	22 686	29 409
Mediterranean	212 784	452 848	1 032	2 213	13 679	20 365
Shellfish	653 318	849 935	1 017	1 445	NA	NA
Total	**1 388 292**	**2 160 867**	**3 490**	**6 174**	**38 504**	**52 639**

Source: European Parliament, The long-term economic and ecologic impact of larger sustainable aquaculture (2014)[4]
** Excludes Norway*

The main challenges to the progress of European aquaculture as described in "The Future of European Aquaculture, (EATiP), 2012"[10] are:

- competition in the marketplace, principally from imports;
- access and competition for space for coastal and inland aquaculture;
- maintaining health and welfare of livestock;
- improving resource use (husbandry, feeds, farm technology);
- governance within the Common Fisheries Policy.

1.4. Scope of the study

The study has investigated the main fish species produced in European aquaculture: Atlantic salmon, common carp, rainbow trout, European sea bass and gilthead sea bream.

It has been limited to the main aquaculture producing EU Member States and other States of the European Economic Area (EEA). Data on each of the five species mentioned above has been collected in at least three countries. Focus has been on collecting in-depth data for the selected years 2009 and 2013 to allow comparisons over a period of time. Key statistics have been collected for all the years from 2009 to 2013 to identify any exceptional year-on-year changes within the period.

Table 3 presents the selection of countries for each species of fish. This selection covers the main production areas for each species and provides a wide distribution over the major production areas in the EEA. In general the higher ranked producing countries are selected, but with some variation to ensure coverage of different countries and types of production.

The consultants consider that the scope of the study as described above, whilst not covering all EEA States, is sufficiently broad to provide a general presentation of the current situation of European aquaculture.

[10] http://www.eatip.eu/default.asp?SHORTCUT=92

Table 3. EEA States included in the study

Fish species**	Country in study	European Rank by production	Production (tonnes) in 2014*	Production type
Atlantic salmon 	Norway United Kingdom Ireland	1 2 4	1 290 000 163 347 10 000	Cold-water marine
Common carp 	Poland Czech Republic Germany	1 2 4	18 000 17 833 5 285	Fresh water
Rainbow trout (Large (L) and Portion (P)) 	Denmark France Italy Poland	(L4 and P3) (L3 and P4) (L9 and P2) (P5)	38 091 34 000 38 800 17 500	Fresh water
European sea bass 	Greece Spain Italy	2 3 4	42 000 17 376 6 500	Mediterranean
Gilthead sea bream 	Greece Spain Italy	1 3 4	71 000 16 230 8 200	Mediterranean

**Source FEAP 2015*[11]*; ** Pictures from: https://ec.europa.eu/fisheries/marine_species_en*

In addition, four non-EEA countries were selected to provide a comparison with major competitors (Table 4):

[11] FEAP, 2015, European Aquaculture production report 2005-204 www.feap.info/shortcut.asp?FILE=1402

Table 4. Non-EEA countries selected for comparison purposes

Country	Fish species	Production (tonnes) in 2014*
Canada	Salmon Atlantic salmon Chinook salmon Coho salmon Trout Rainbow trout Steelhead trout	173 452
Chile	Salmon Atlantic salmon Chinook salmon Coho salmon	1 071 421
China	China is the global leader in aquaculture with multiple species and is an important export market for certain species produced by EEA States	41 108 306
Turkey	European sea bass Gilthead sea bream	212 805

**Source: FAO yearbook Fishery and Aquaculture Statistics 2012 (*http://www.fao.org/3/a-i3740t.pdf)

The research in the selected non-EEA countries has focused on aspects related to trade and competitiveness of the EEA aquaculture industry. It has been limited to the species in the study.

Data has been collected on domestic production and import/export trade for the species in the study in each of the selected non-EEA countries. In Chile and Canada, the main focus has been on their salmon exports to markets where they compete with products from the EEA States. In Turkey, the focus has been on its sea bass and sea bream exports. In China, the focus has been on the import market for EEA salmon and trout. Other fish species such as tilapia and pangasius have not been included.

The following points provide clarification on the aspects of transport and slaughter that have been covered by the study:

- 'Transportation' includes preparation of the fish for transport, crowding at the farm, loading the vehicle, monitoring during transport, and unloading at a slaughter facility or facility for on-growing.
- 'Crowding' means herding fish by decreasing the space available for swimming in a cage, pond or tank. Crowding is performed to facilitate transfer of fish from a cage, pond or tank to a transport vehicle or for another purpose.
- In general, only transport of marketable fish to a slaughterhouse has been evaluated. However, the transport of fry[12] or fingerlings/juveniles and smolt to a farm for on-growing were also evaluated for sea bass and sea bream (fry) and Atlantic salmon (smolt). In the economic models, it is included as an extra cost of fry or fingerlings/juveniles and smolt. Internal movements between rearing systems within a farm were not be evaluated.
- 'Slaughter' includes handling for transfer to equipment for stunning and killing (this may include crowding, depending on the fish species or the technology used), restraining, stunning and killing.

[12] Fry may include all fish stages from hatching to fingerling (www.fishbase.org)

- 'Restraining' is fixation of an animal for the proper application of a stunning method, for instance, the fish is placed in a small tank with water to apply electrical stunning (Van de Vis *et al.*, 2014).
- The role of SMEs has been included in the assessment of the factors that promote, restrict or prevent the use of humane transport, handling, stunning and killing methods under specific objective 3 (see section 1.2.2).
- The study Steering Group commented that economic models should consider the danger of extrapolating the premium paid by certain consumers for welfare to all species. No extrapolation was done from the economic models as the economic assessment was restricted to existing practices.

1.5. PRESENT REGULATION AND POLICY BEING EVALUATED

Farmed fish are covered by the scope of EU legislation on the protection of animals during transport and at the time of killing, but without specific rules. As a result, the EU Strategy for the Protection and Welfare of Animals, 2012-2015[13] proposed to investigate the welfare of farmed fish.

Article 27(1) of Regulation (EC) No 1099/2009 on the protection of animals at the time of killing requires that the Commission shall submit to the European Parliament and the Council a report on the possibility of introducing certain requirements regarding the protection of fish at the time of killing, taking into account animal welfare aspects as well as the socio-economic and environmental impacts.

Regulation (EC) No 1/2005 applies with regard to the welfare of farmed fish during transport. However, the Commission has noted that implementation of the Regulation has encountered some difficulties with regard to farmed fish and some other categories of animals, as the detailed rules refer particularly to livestock. The Commission therefore launched this study to gain a better understanding of the situation regarding the welfare of farmed fish during transport and stunning/killing.

Consumers, producers and authorities are increasingly concerned about animal welfare and such ethical and moral considerations influence societal acceptability of animal production[14]. This animal welfare debate has tended, however, to focus on terrestrial species. But fish welfare is also receiving increased attention. For example, a recent study showed that the Norwegian public is concerned about fish welfare and is willing to pay a price premium for products made from welfare-assured fish. Norwegian consumers do not, however, want to be the only ones paying for fish welfare, as they consider that the main responsibility for fish welfare lies with producers and the government[15].

With regard to the main fish species farmed in the EU, the European Food Safety Authority (EFSA) in 2009 published several opinions on the welfare aspects of the main systems of stunning and killing. The main hazards identified were:

- handling or handling-related procedures (e.g. crowding, pumping, time out of water);
- water quality in holding tanks/pens;
- stunning and killing methods.

[13] COM(2012) 6 final/2

[14] Frewer, L.J. A. Kole, S.M.A. Van de Kroon, C. De Lauwere, 2005, Consumer attitudes towards the development of animal-friendly husbandry systems, Journal of Agricultural and Environmental Ethics, 18 pp. 345–367

[15] Kristian Ellingsen , Kristine Grimsrud , Hanne Marie Nielsen , Cecilie Mejdell , Ingrid Olesen , Pirjo Honkanen , Ståle Navrud , Christian Gamborg , Peter Sandøe , (2015) "Who cares about fish welfare?: A Norwegian study", British Food Journal, Vol. 117 Iss: 1, pp.257 – 273

It was concluded that many of the methods and much equipment in use at the time resulted in poor fish welfare. For this reason, EFSA proposed recommendations, both for the pre-slaughter and the stunning and killing operations. It was also emphasised that opportunities for development of new methods for stunning or killing, for all of the fish species assessed, were considerable[16].

EFSA's activities in the area of fish welfare are carried out in the wider context of animal health and welfare by the Panel on Animal Health and Welfare (AHAW). The Panel provides independent scientific advice to risk managers on all aspects of animal diseases and animal welfare. Its work chiefly concerns food-producing animals, including fish.

EFSA does not have a mandate to give advice on ethical or cultural issues related to animal welfare[17]. Through its activities on fish welfare, EFSA aims to gain an in-depth understanding of the factors affecting the welfare of farmed fish and to provide a science-based foundation for European policies and legislation. Its scientific opinions focus on helping risk managers identify methods to reduce unnecessary pain, distress and suffering for animals and to increase welfare where possible.

Opinions on welfare during fish transport were published in 2004. In this study EFSA experts identified a variety of hazards that contribute to poor welfare for several animals, including fish. The opinion highlighted that fish should normally be loaded and unloaded avoiding exposure to air, they should be provided with appropriate levels of oxygen in the water and maintained at a suitable stocking density.

Regarding stunning and killing methods, in 2009 the AHAW Panel adopted species-specific opinions on the welfare aspects of stunning and killing methods for farmed fish. The individual scientific opinions concerned Bluefin tuna, common carp, European eel, Atlantic salmon, rainbow trout, European turbot, European sea bass and gilthead sea bream. This work updates the previous opinion on the welfare aspects of stunning and killing for the main animal species subject to commercial and farm slaughtering practices, which was adopted on 2004 and where general conclusions and recommendations were provided.

The World Organisation for Animal Health (OIE) has adopted guidelines concerning the stunning and killing of farmed fish for human consumption and the welfare of farmed fish during transport. As these apply to EEA States as OIE members, they are relevant to this study.

OIE animal welfare standards have been used in the study as a benchmark for comparison of welfare practices. In addition, EFSA recommendations on slaughter are also taken into account.

The Commission intends to boost the aquaculture sector through the Common Fisheries Policy reform. In 2013 it published Strategic Guidelines[18] presenting common priorities and general objectives at EU level. Four priority areas were identified in consultation with stakeholders to help increase the sector's production and competitiveness[19]:

1. Reducing administrative burdens,
2. Improving access to space and water,
3. Increasing competitiveness,
4. Exploiting competitive advantages due to high quality, health and environmental standards.

As improving fish welfare during transport and at slaughter is likely to have cost implications, but could also lead to gains (e.g. better fish meat quality), economic factors have been taken into

[16] Scientific Opinion of the Panel on Animal Health and Welfare on a request from the European Commission on Species specific welfare aspects of the main systems of stunning and killing of farmed fish, http://www.efsa.europa.eu/en/topics/topic/fishwelfare Ref. Ares(2016)1840131 - 19/04/2016
[17] http://www.efsa.europa.eu/en/topics/topic/fishwelfare
[18] http://ec.europa.eu/fisheries/cfp/aquaculture/official_documents/com_2013_229_en.pdf
[19] http://ec.europa.eu/fisheries/cfp/aquaculture/index_en.htm

account in a cost analysis of existing animal welfare practices. However, an assessment of the potential impacts of new or improved practices is not required.

2. MATERIALS AND METHODS

2.1. APPROACH TO COLLECTING THE DATA

Data collection involved a stepwise approach using the following sources:

1. Desk research: literature review and database searches using STECF[20] and Eurostat; data originating from other sources including sector organisations at EU, EEA and national levels
2. Consultation: data collected by on-line survey; targeted stakeholder interviews, and focus groups.

For the purpose of this study, we differentiated between common, standard practices (adherent to legal requirements) and good welfare practices that are near[21] or fully adherent to (or even go beyond) OIE standards during transport and during stunning and killing for human consumption, to enable comparison on welfare and economical aspects of common and more advanced welfare practices (see Table 5).

Table 5. Categorisation of welfare practices during transport and at slaughter

Common practices	OIE Standards
Common, standard practices (adherent to legal requirements, partially OIE adherent)	Near or fully OIE adherent, or beyond OIE

2.2. SETTING THE SCENE: DESK RESEARCH

The desk research consisted of literature review and database searches on the welfare of fish during transport and slaughter and on financial information relating to the sector, by searches using STECF and Eurostat data bases. The literature review covered both methodological and empirical international literature. Peer-reviewed articles and congress papers were used to provide information and to guarantee the reliability of the literature review. Websites, technical journals and grey literature were also consulted as these may contain further useful information.

As the expert team consisted of international experts in aquaculture, the literature review was partly an update of the information sources already available to the team. The team was aware of the DG SANTE audit missions performed on the topic of slaughter to various EEA States in 2015 and examined the findings of these missions.

This desk research provided information for the farmed fish welfare and economical assessment, identified gaps in the information, and provided the basis for the surveys and questions to stakeholders and focus groups.

The websites and references are included in Annex 4, together with the search terms.

[20] Scientific, Technical and Economic Committee for Fisheries http://ec.europa.eu/fisheries/partners/stecf/index_en.htm

[21] Near: containing the major requirements of the OIE standard

2.3. CONSULTATION

2.3.1. ON-LINE SURVEY

Data collected by on-line survey

The aim of the survey was to complete as far as possible the European picture of welfare of the five farmed fish species under this study during transport and at slaughter. Firstly, the list of stakeholders was updated to identify suitable organisations and individuals to fill in the questionnaires.

We distinguished three groups of stakeholders in each country of the survey:

1. Competent Authority (CA)
2. Industry representatives (including fish producers, transporters and equipment manufacturers)
3. Animal welfare organisations, including NGOs active in fish welfare

Specific questions were asked in a targeted on-line survey in a selected number of EU Member States and EEA-EFTA States.

We prepared specific on-line questionnaires to targeted stakeholders. The draft questionnaires were submitted to the Commission for review and approval. The questionnaires were tested on-line by a Dutch CA representative and by a representative from DG SANTE and adjustments were made. The questionnaire responses validated information from the desk research phase, obtained information on gaps that were identified, and provided input for interviews and focus groups. The list of targeted stakeholders is included in Annex 1.

Based on previous experience, it was important to use targeted surveys aimed at acquiring specific types of information from specific target groups. The surveys were limited in the number of questions, restricted in allowing open responses, and set up using Likert scales, numbering, and ranges, to facilitate the analysis. The surveys were prepared in English.

2.3.2. TARGETED STAKEHOLDER INTERVIEWS

On the basis of the literature review and the on-line survey, templates were prepared for semi-structured interviews with representatives of professional organisations at EU and EEA levels, and with selected stakeholders in the EEA States. To obtain information from the field, the focus was on interviewing industry representatives, inspectors and auditors, representatives from NGOs, and individual sector experts.

The actual number of interviews required with the industry in each country depended on whether slaughter was carried out on-farm (involving no transport) or in an abattoir, and also on variations between species.

The interviews were carried out using a questionnaire template presented on-line to facilitate uniformity in the questions and responses. The aim was to identify the common practices related to transport and slaughter of farmed fish and identify problems and challenges regarding implementation of best practices

When required, questionnaires were translated into the local language. Reporting back to the project team was conducted in English.

The approved stakeholder questionnaires and the interview templates are included in Annex 2.

2.3.3. FOCUS GROUPS

Four focus groups were organised: one for salmon, one for carp, one for trout, and one for sea bass and sea bream combined. The focus groups provided a network of individual experts for the expert team for information, commented on data collected and supported the analysis during the different stages of the study Annex 3).

By sharing and discussing information between countries, the focus groups helped to ensure consistency of the research and findings across the countries.

The focus group members were consulted concerning relevant issues and analyses at national and international level.

The focus groups included representatives of aquaculture associations, national and/or regional administrations, producer groups and other relevant stakeholders, as appropriate in the different countries.

To be effective and manageable, each focus group had a maximum of ten representatives. As each species was surveyed in three EEA States, each focus group had, on average, three members from each surveyed country, plus a representative from the core study team.

As the focus group members were widely distributed across Europe, most contacts took place through email exchange and by discussions in 'virtual' meetings, such as Skype calls.

2.3.4. DATA COLLECTION FOR SELECTED NON-EEA COUNTRIES

Data collection in the non-EEA comparison countries (Canada, Chile, China and Turkey) used targeted interviews. Data were also collected from FAO and national statistical resources from both government and industry. Where there were gaps in the data, Wageningen University's extended network within these countries was used to find alternative sources.

The aim was to provide insight in welfare practices and competitiveness regarding prices for the various species evaluated in the selected non-EEA countries.

Based on the analysis, the impact of animal welfare measures on different aspects of competitiveness of European aquaculture was analysed. This assessment covered the five fish species in the study. The impact assessment includes economics, trade, knowledge needs, equipment costs and availability and potential effect of acceptance by retail and consumers.

2.3.5. RELIABILITY OF INFORMATION

The questionnaires and interview templates were tested on a sample of participants to verify the usability and clarity of responses before use in the case study countries. The questionnaires were discussed and approved by the Commission. The information collected by the on-line survey and interviews was validated by cross-checking with literature data and reports, such as those of DG SANTE Directorate F - Health and Food Audits and Analysis (formerly FVO).

2.4. COLLECTING DATA AND OBSERVATIONS ON ANIMAL WELFARE PRACTICES

The first study activity consisted of collecting data and observations on animal welfare practices. Current practices during transport and at slaughter were described, and a comprehensive literature search was performed using the Aquatic Sciences and Fisheries Abstracts (ASFA) database. The literature search was supplemented by a search using Google.

The search queries are presented in Annex 4. Within each a query we narrowed the results to obtain data per fish species per country.

Regarding information on animal welfare practices, we assessed the following subjects:

- Aspects relevant to the evaluation of fish welfare. In Chapter 7 of the Aquatic Animal Health Code[22], the OIE developed international standards for the welfare of farmed fish (excluding ornamental species) during transport, stunning and killing for human consumption, and killing for disease control purposes. The OIE Aquatic Code is the guiding document for the assessment of welfare of farmed fish during transport and at slaughter. In this code detailed recommendations are given to ensure the welfare of farmed fish during transport (Chapter 7.2) and stunning and killing for human consumption (Chapter 7.3)[23]. Welfare issues relevant for transport and for stunning and killing have been checked for each fish species, and are shown in Table 6 and Table 7 below.
- The relevant welfare issues. These include the type of transport vehicles/vessels, age of transport equipment, duration of transport, handling (e.g. procedures, time, and equipment), water quality, feed deprivation prior to transport and/or slaughter, and stunning and killing methods used.
- National legislation or codes of practice that regulate the welfare aspects of transport and slaughter of farmed fish.
- Existing private standards (that may be voluntary) which cover fish welfare aspects.
- The availability and cost of commercial handling and stunning equipment, which would allow the application of international animal welfare standards.
- The availability of animal welfare training programmes as recommended by the OIE international standards.
- The extent that implementation of the OIE international standards is affected by the commercial availability of the necessary equipment or methods. The present state-of-play regarding fish welfare during transport and slaughter is assessed.

[22] http://www.oie.int/index.php?id=171&L=0&htmfile=titre_1.7.htm

[23] Recommendations regarding killing of farmed fish for disease control purposes are given in Chapter 7.4 However this part of the Code is beyond the scope of the project.

Table 6. Issues for review of transport methods used for Atlantic salmon, rainbow trout, gilthead sea bream, European sea bass and common carp

Fish species	Means of transport	Life stage of the selected fish species	Stage of production	OIE article
Specify	1 Road 2 Sea 3 Air	Specify whether fry/fingerling or juveniles (or smolt in case of Atlantic salmon) or marketable fish are transported.	Is there a contingency plan for all phases of transportation? How are sick, injured or moribund fish during transport treated?	7.2.1; 7.2.2; 7.2.3; 7.2.4; 7.2.5; 7.2.6; 7.2.7; 7.2.8; 7.2.9
			<u>Information provided by the farm to hauler</u> Are the fish fit for travel? Major injuries, diseases are absent. Fish are not moribund; how are these aspects assessed?	7.2.1; 7.2.4; 7.2.5
			<u>Information provided by the farm to the hauler</u> What is the length of feed deprivation; how many degree days? Is the feed deprivation sufficient to clear the gut? Are there other methods used to prepare the fish for transport?	7.2.1; 7.2.4; 7.2.5
			Is the transport planned by the hauler? Is there a protocol available? Is a vehicle designed for this purpose? Is the vehicle maintained and cleaned prior to transport? What it the age of the vehicle? Are the post-transport activities described (receipt of fry/smolt at farm for on-growing or marketable fish at abattoir)? Specify.	7.2.1; 7.2.2; 7.2.4; 7.2.5; 7.2.9
			Crowding in holding tank or cage? Crowding practices inclusive of total duration of crowding. Monitoring of oxygen levels during crowding? Skill of personnel	7.2.3; 7.2.6
			Which type of equipment is used to take fish out of the holding tank/cage, e.g. fully automated? e.g. brailing or pumping? Specify pump height and speed. Is it fully automated? Specify the routines for maintaining good water quality for duration of transfer. Are the fish out of water? Length of time out of water? Are fish injured due to faulty constructions/fittings? Skill of personnel. Operation of equipment, is it according to manufacturer's recommendation?	7.2.3; 7.2.6
			Loading the transport vehicle. Which type of equipment is used? Is it fully automated? e.g. brailing or pumping? Specify pump height and speed.	7.2.3; 7.2.6

Fish species	Means of transport	Life stage of the selected fish species	Stage of production	OIE article
			Specify the routines for maintaining good water quality for duration of loading. Handling out of water? Length of time out of water. Skill of personnel. Operation of equipment, is it according to manufacturer's recommendation?	
			Specify the duration of transport in relation to means of transport used. Is sedation or anaesthesia applied during transport? Specify the routines for maintaining good water quality for duration of transport. Which water quality parameters are monitored during transport? Are stops made to change transport water? Are the fish observed during transport; how? Skill of personnel. Operation of vehicle for transport, is it according to manufacturer's recommendation?	7.2.3; 7.2.7
			Specify the percentage of transports that operate with closed systems. Specify available equipment for water quality maintenance in closed systems Specify Monitoring of water quality parameters in closed systems.	7.2.5;
			Unloading the transport vehicle. Which type of equipment is used? Is it fully automated? e.g. brailing or pumping? Specify pump height and speed. Specify the routines for maintaining good water quality for duration of unloading. Handling out of water? Length of time out of water. Skill of personnel. Operation of equipment, is it according to manufacturer's recommendation?	7.2.8

Table 7. Issues for review of stunning and killing at abattoirs or farms used for Atlantic salmon, rainbow trout, gilthead sea bream, European sea bass and common carp

Fish species	Method used for stunning and killing of the selected fish species	Stage of production	OIE article
Specify	1 Electrical stunning in water followed by killing 2 Electrical stunning after dewatering followed by killing 3 Percussive stunning 4 Live chilling	Is there a contingency plan for all phases of stunning and killing? e.g. is there a backup system in case of mis-stuns?	7.3.1; 7.3.2; 7.3.3; 7.3.4; 7.3.5; 7.3.6; 7.3.7
		Routines for maintaining good water quality in holding tanks/pens.	7.3.1; 7.3.4

Fish species	Method used for stunning and killing of the selected fish species	Stage of production	OIE article
	combined with carbon dioxide followed by a killing method 5 Live chilling followed by a killing method 6 Carbon dioxide stunning followed by killing 8 Anaesthetics 9 Any other stunning and killing method	Duration of holding fish prior to commencing slaughter.	
		Logistics of handling procedures. Are fish consecutively handled to ensure that they proceed rapidly to stunning and killing or are they handled intermittently?	7.3.2
		Duration of holding fish prior to commencing slaughter; duration feed deprivation at an abattoir or farm. Specify the reason when the holding the fish exceeds 6 h prior to commencing the process of slaughter.	7.3.4
		Crowding in holding tank or cage? Crowding practices inclusive of total duration of crowding. Monitoring of oxygen levels during crowding?	7.3.5
		Which type of equipment is used to take fish out of the holding tank/cage, e.g. fully automated? E.g. brailing or pumping? Are fish injured due to faulty constructions/fittings?	7.3.5
		Are conscious fish subjected to any treatment to make the animals calm or reduce their metabolic rate? Specify the method used.	7.3.5
		Is a stunning method applied?	7.3.1; 7.3.6
		Transfer into stunner. Which type of equipment is used? Handling out of water? Length of time out of water. Is orientation of the fish required? Are fish injured or subjected to sub-optimal conditions for stunning due to faulty constructions/fittings?	7.3.2; 7.3.6; 7.3.7; 7.3.8
		Which specifications are used for stunning? Do checks of state of consciousness occur? Skill of personnel	7.3.2; 7.3.6; 7.3.7
		Is a killing method applied? Or is the stun irreversible?	7.3.1; 7.3.6
		No exceedance of established time interval between stunning and application of killing method?	7.3.6; 7.3.7
		Specify killing method (e.g. gill cut, chilling or other method)? Skill of personnel	7.3.2; 7.3.6; 7.3.7; 7.3.8

2.5. COLLECTING DATA AND OBSERVATIONS ON ECONOMIC ASPECTS

The second study activity consisted of data collection on economic aspects of aquaculture production in the selected EEA States and non-EEA countries.

For each combination of EEA State and fish species, data was collected in the selected States on the structure of the aquaculture sector regarding production, transport and slaughter. In-depth data collection was focused on the selected years 2009 and 2013 in order to assess overall changes over the five-year period. Key statistics were examined for all the years from 2009 to 2013 in order to indicate any exceptional differences from year to year.

For the selected non-EEA countries, key statistics were collected for the years 2009 and 2013.

Scientific, Technical and Economic Committee for Fisheries (STECF)

The European Commission has established a Scientific, Technical and Economic Committee for Fisheries (STECF). The STECF is consulted at regular intervals on matters pertaining to the conservation and management of living aquatic resources, including biological, economic, environmental, social and technical considerations.

Among other tasks, the STECF draws up an annual report on European Aquaculture. In order to fulfil its task, the STEFC asks the EU Member States to deliver economic data on commercial fish farms. These data are put into an extended database, containing economical and technical information of many fish farms all over Europe.

For several reasons the STECF database is chosen as the base for the economic calculation model:

- good availability and accessibility;
- data are available for several years;
- built on authority of the EU;
- contains almost all data needed for the economic calculation model;
- contains data from several EU Member States;
- contains data for several species, environments and production methods;
- standardised approach for different species and countries, and;
- the database is up to date.

Some disadvantages of the database are:

- not all combinations of Member States and species are available, including some important combinations (such as carp in Poland, Germany and the Czech Republic);
- the database does not contain Norwegian data;
- not all species required in this study are available (e.g. shrimp, seaweed);
- sea bass and sea bream are not separated;
- the density rate is not available, and;
- not all variables are actually filled in.

Available data in the STEFC database

Table 8 shows the relevant available data in the STEFC database. Data are provided for farm outputs as well as for farms inputs. For some important issues (sales, livestock, feed and labour) also the volumes are available[24].

Table 8. Overview of available data in the STECF database

Categories	Units	Variables
Farm outputs	Euro	Turnover
		Subsidies
		Other income
Farm inputs	Euro	Raw material costs: Livestock costs
		Raw material costs: Feed costs
		Other operational costs
		Wages and salaries
		Imputed value of unpaid labour
		Repair and maintenance
		Depreciation of capital
		Financial costs, net
		Energy costs
		Extraordinary costs, net
Farm income	Euro	Total income
Employees	Number	Total employees
		Male employees
		Female employees
Employees	FTE	Total employees
		Male employees
		Female employees
Volumes	Kg	Total sales volume
		Raw material volume: Livestock
		Raw material volume: Feed
Balance sheet	Euro	Total value of assets
		Net Investments
		Debt
Enterprises by size	Number	Number of enterprises
		Number of enterprises <=5 employees
		Number of enterprises 6-10 employees
		Number of enterprises >10 employees

Table 9 shows the data available in the STECF database for the fish species included in the study[25].

Since some important combinations of species and production regions were missing in the STECF database, such as carp production in Poland and the Czech Republic, and salmon production in

[24] Besides data on species reviewed in this study, the database also contains data for the species clam, mussel, oyster, other fresh water fish, other salt water fish, and other shellfish.

[25] STECF, 2014. The economic performance of the EU aquaculture sector (STECF 14-18). Publications Office of the European Union, Luxembourg, EUR 27033 EN, JRC 93169, 451 pp

Norway; where possible, other data sources were used for these species. The Norwegian Directorate of Fisheries (Fiskeridirectoratet Norge) provides data for the Norwegian salmon production[26]; Turkovski and Lirski published the profitability of the Polish carp sector[27] and the Landesfischereiverband Brandenburg provides a model for carp production in Germany[28]. These data were manually incorporated into the database to complete the data for our analysis.

Table 9. Availability of data for EU Member States, fish species and years

Country	Salmon	Trout (fresh water)	Carp	Sea bass/ Sea bream
Bulgaria		2008-2012	2012	
Croatia		2011-2012	2011-2012	2011-2012
Cyprus				2008-2012
Denmark		2008-2012		
Estonia		2008-2012		
Finland		2008-2012		
France		2008-2012		2008-2012
Germany			2012 2)	
Greece	2008	2008-2012		2008-2012
Ireland	2008-2012	2008-2012		
Italy		2008-2012		2008-2012
Norway	2008-2012 1)			
Poland	2009-2012		2008-2012 3)	
Portugal		2008-2012		2008-2012
Romania		2009-2012	2009-2012	
Spain	2011-2012	2008-2012	2008-2012	2008-2012
Sweden		2009-2012		
UK	2012	2012	2012	

1) source: Fiskeridirektoratet Norge
2) source: Landesfischereiverband Brandenburg/Berlin
3) source: Turkovski and Lirski, 2013

Data collection in countries not available in the STECF database

For each combination of non-EEA country and fish species, data was collected on animal welfare practices and how they relate to production volume and value in the country itself and the export to the EU in volume and value for the selected years 2009 and 2013. Important sources of information were statistics of FAO and the United Nations (UN) Comtrade Database[29].

2.5.1. Stakeholder interviews in EEA States

Qualitative interviews were carried out with national sector organisations for each combination of EEA State and fish species to identify the most commonly used methods of transportation and slaughter with regard to welfare. Examples and contacts of companies which use common practice and additional (good) welfare practice were collected.

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[26] Fiskeridirektoratet Norge 2013. Profitability survey on the production of Atlantic salmon and rainbow trout. Bergen (Norway), ISSN 1894-2881
[27] Turkovski, K., Lirski, A. 2013. The economics of carp farms in Poland. Acta Ychtiol. Piscat. 40 (2):137-144
[28] Landesfischereiverband Brandenburg / Berlin 2014. Kalkulationsmodell Karpfenteichwirtschaft. Model published on www.lfvb.org
[29] https://comtrade.un.org/

2.5.2. In-depth data collection in EEA States

In the case-study EEA States, detailed data on transport and slaughter for each fish species investigated were collected, focusing on the selected years 2009 and 2013. These data have been used to gain insight into the costs and benefits of implementing welfare practices on average sized enterprises, differentiated by selected fish species and country. The data also allows the identification of important changes over time.

A triangulation of methods was used for this data collection:

a) Collection of data from companies:

The aim was to collect data for each combination of selected country/fish species for at least two companies involved in transportation and two companies involved in slaughter, and compare different welfare practices. We compared different common practices, or compared one enterprise adhering to common practices (adherent to legal requirements) and one that was near or fully adherent with the OIE international standards, or even beyond them.

The aim was to compare companies processing about the same volumes of fish. In cases where companies where not willing to provide all the required data, other sources of information – such as producer associations – were used to estimate these values for an average volume of fish.

The different country/fish species combinations under study provide a data set of companies involved in transportation and in slaughter.

Wageningen Economic Research has checked the quality of the data through an internal validation in which indicators for volume of fish, number of employees and total value of assets were calculated and compared to other case countries and fish species. In this way, possible outliers were identified. Where necessary, follow-up contact was established to collect missing data or improve data quality.

b) Data from other sources

Where possible and relevant, the calculated indicators have been compared with similar indicators from other statistical sources, including national statistics, EUROSTAT, FADN (Farm Accountancy Data Network - agriculture and fisheries), STECF and the UN Comtrade Database. The statistics might include, for example, salary costs per employee and interest rates. Any missing data was estimated using these statistical sources.

c) Expert validation

Members of the focus groups for each fish species were contacted to review or comment on the information. The members were involved to discuss the effect of the additional costs and benefits of adhering to additional welfare practice as listed in OIE standards on the outcome of the model calculations (see next step).

2.5.3. Model calculations of the additional costs and benefits in EEA States

Finally, for each of the 16 country/fish species combinations under study, the additional costs and benefits per kilogramme of live fish of adhering to better welfare practices are calculated for an average enterprise.

These calculations enable an assessment of the economies of scale as the average sizes of the companies involved in transportation and slaughter vary substantially between the case study countries. To get an insight into the effect of enterprise size on the costs of adhering to welfare practices, the calculations were performed for different farm sizes.

2.5.4. ANALYSING

Analysis and presentation of results, consistency checks and discussion was led by Wageningen Economic Research.

2.5.4.1. EVALUATING WELFARE PRACTICES BY PARTIAL BUDGETING

To gain insight into the additional benefits and costs an organisation has to make to improve animal welfare practices, two methods can be used (Belli 2001[30]):

- a before-and-after approach, or;
- a with-and-without comparison.

Applying a before-and-after approach requires insight into the actual investments, benefits and costs and resulting changes in cost price. Improvements in animal welfare are mostly part of larger investments, so welfare-related benefits and costs have to be deduced and estimated from financial statements of individual companies.

The before-and-after comparison fails to account for changes in production that would occur without the improvements and thus may lead to an erroneous statement of the benefits and costs attributable to the improved welfare practices. Attempts were made to retrieve such detailed economic data related to fish welfare practices from aquaculture producers. However, these data were not available or producers were unwilling to share such commercially sensitive information.

The with-and-without comparison attempts to measure the incremental benefits and costs arising from implementing improved welfare practices, and was used here to get insight into the impact of welfare related investments on the competitiveness of the EU aquaculture industry. For each of the investigated species in the case countries, the effects on the benefits and costs for an average enterprise were calculated. For the evaluation, it is assumed that an average enterprise for the investigated species in the case countries has not previously implemented any welfare practices, so the total benefits and costs of adhering to the improved welfare practices are calculated.

To understand the economic implications of interventions to improved welfare, a partial budgeting framework was used. Table 10 illustrates the approach.

Table 10. Calculating costs and benefits using partial budgeting

Costs for a specific transport, stunning or killing practice	Benefits
A. Additional costs	C. Additional revenue
B. Reduced revenue	D. Reduced costs
Total costs = A + B	Total benefits = C +D
Net change in profit = (C+D)–(A+B)	

The change in benefits and costs is calculated using a costing approach consisting of the following steps:

- The additional yearly costs (A – D) are calculated from the investment in new equipment, the dis-investment in replaced equipment and the corresponding depreciation periods, interest and maintenance costs for this equipment. If relevant, changes in labour requirements and energy costs are also be included. This information is collected from manufacturers and experts.

[30] Belli, P. (2001). Economic analysis of investment operations: analytical tools and practical applications. Washington, D.C, World Bank.

- The additional and reduced revenues are calculated from the expected changes in sales volume and/or product price (C – B) according to research and expert opinions.
- Based on the data collected, the change in cost price per kilogramme of product produced will be calculated for an average-sized enterprise for the investigated species in the case countries to compare the base-line situation and the situation with improved animal welfare.
- A sensitivity analysis was performed by calculating the effect of cost price per kilogramme of product for different sizes of the enterprise.

These cost prices give insight into the competitiveness of aquaculture in the evaluated countries.

2.5.4.2. Evaluating practices to improve animal welfare

To assess the impact of implementing animal welfare practices, the economic data presented in Table 11 were collected.

Table 11. Economic data to be collected to evaluate the impact of animal welfare practices

Indicator
Investment costs of the improvement (both the costs of the equipment and the installation)
Maintenance costs
Additional of saved labour costs (including training and start-up costs)
Increased or decreased revenues due to change in volume or quality of the fish

A gap analysis was performed on the development of equipment and the research necessary to apply provisions of the OIE standards.

Based on the data collected, the cost price per kilogramme of product produced was calculated for the base line situation and for the situation with improved animal welfare. This cost prices give insight into the competitiveness of aquaculture in the evaluated countries.

2.5.4.3. Evaluating competitiveness

Approaches to evaluate the development of the competitiveness of aquaculture production in the selected countries can be based on the following indicators, depending on available data (Wijnands, J.H.M. and D. Verhoog, 2016):

1. Difference of the export shares on the world market between two datasets of a specific subsector of the aquaculture industry or the food industry as whole. The market share of one country is compared with the total world export of that industry or subindustry. This performance indicator reflects the outcome of the competitive process.
2. The difference of the Relative Trade Advantage (RTA) index between two periods. A positive RTA indicates a competitive advantage: the exports exceed the imports. Negative values signify competitive disadvantages.

Economic performance:

3. Annual growth of the value added of a specific industry in the total manufacturing industry. This reflects the competition for product factors between different industries within a country.
4. Annual growth of the value added per employer as indicator for labour productivity. This productivity measure affects the unit labour costs and in this way the relative prices.
5. Annual growth of value added reflects the performance of that specific industry or sub-industry compared to those in other countries. For this, Canada, China, Chile and Turkey were used as comparison countries

Impact of animal welfare practices on competitiveness:

6. Determination of the effect of improved fish welfare during transport and at slaughter for the selected fish species on the competitiveness of the EEA States compared to the selected non-EEA countries. After the differences in welfare practices between the EEA States and the non-EEA countries are determined, the data in the EEA States are used to determine the difference in factor costs that can be attributed to differences in animal welfare. This is done to determine how much of the differences in competitiveness in aquaculture can be attributed to the (non)-implementation of welfare practices during transport and at slaughter.

3. Results and observations from data collection activities

This chapter describes the general results of the data collection activities (Tasks 1 and 2) of the study.

3.1. Main results of stakeholder consultation and focus groups

Targeted on-line survey

On December 21, 2017 the approval for launch of the questionnaires was granted and the questionnaires were submitted by email with a link to the on-line questionnaire system (E-survey). After two weeks, non-responders were reminded by email and by telephone calls (to EEA State CAs). In every country, sector representatives were also reminded.

Responses were low for the sector and initially also from animal welfare organisations, and moderate for EEA State CAs. It is particularly unclear why several CAs did not respond – telephone contacts were co-operative but did not result in completion and return of the questionnaires. Regarding the NGOs, after direct contact we received six responses from animal welfare organisations. Out of six completed questionnaires received from NGOs, two did not contain much detailed information.

Industry representatives were generally co-operative when contacted and the low response rate was thought to be due to difficulties and time required for recovering all the relevant data, particularly when it dated back to the reference period (2009-2013). In some cases, the industry may have been reluctant to provide commercially sensitive data.

The response rates are shown in Table 12.

Table 12. Response rate to targeted questionnaires

Category	Invitees	Respondents	Remarks
EEA State Competent Authorities (CAs)	11	9 (CZ, DE, DK, ES, IT, GR, NO, PL, UK)	No replies from FR, IE
Industry	75	8	Industry was subsequently approached by targeted interviews
National and international animal welfare organisations	9	6	Replies received in Q1-Q2 2017

Data collected by interviews

From the stakeholder list, companies were selected based on country and fish species, and whether they were active in transport and/or stunning/killing of fish. The purpose was to obtain detailed information on practices and costs. The expert team prepared specific questions for the interviews in order to facilitate uniform data gathering across countries and to structure replies and analysis. The questions were also made available on-line. The questions were specifically targeted to industry representatives in the selected countries. Country experts were involved to approach relevant industry stakeholders. The final questionnaires for transport and for stunning/killing are included in Annex 2. For completion and validation, additional interviews were also held with industry representatives, inspectors and auditors, representatives from NGOs, and individual sector experts.

The number of completed stakeholder interviews is presented in Table 13.

Table 13. Number of completed stakeholder interviews

Fish species	Country in study	Producers		Processing industry and Equipment Manufacturers	Inspectors/ auditors	NGOs	Farmed fish experts
		Transport	Stunning/Killing				
Atlantic salmon	Norway	1	1	5	1		2
	United Kingdom	-	-	2	2	1	
	Ireland	1	1	2			
Common carp	Poland	6	2	1			1
	Czech Republic	-	-				2
	Germany	2	2	1		1	1
Rainbow trout (Large (L) and Portion (P))	Denmark	-	1	1	1		
	France	-	-	1	1		1
	Italy	-	-		1		
	Poland	1	1	2			
European sea bass	Greece	3	3	2			
	Spain	2	2	1			1
	Italy	-	1	2			2
Gilthead sea bream	Greece	3	3	2			
	Spain	2	2	1			1
	Italy	-	1	2			2
	Total	21	20	25	6	2	13

The analysis of the findings is discussed in chapters 5-11.

3.1.1. Stakeholder consultation – on-line survey

For the on-line survey, we distinguished three groups of stakeholders in each EEA State surveyed: Competent Authority; industry representatives (including fish producers, transporters and equipment manufacturers), and; animal welfare organisations, including NGOs active in fish welfare.

3.1.1.1. Competent authorities (CAs)

From the EEA CA responses the main results were insight in the opinion of the CA on implemented national legislation regarding Regulation (EC) No 1/2005 on the protection of animals during transport and related operations, and Regulation (EC) No 1099/2009 on the protection of animals at the time of killing, and how inspection is accomplished. Other topics were official controls, training, private quality assurance and control, public concern, and economic aspects.

The received responses were most complete on national legislation and official controls, and to a lesser extent on private quality assurance and control, public concern, economic aspects, mortality during transport, and stunning/killing practices. When we compared the responses to results from DG Health and Food Safety, Health and Food Audits and Analysis Directorate's reports, several inconsistencies appeared. These are described in section 5. Review of national legislation, and section 7. Information on equipment and training.

On public concern, three out of eight CAs replied that the public concern for animal welfare had increased, whilst five out of eight mentioned a change or decrease. On quality standards and economic aspects, CAs had less complete responses, which may be explained by limited responsibilities.

Few and inconclusive replies were received on how CAs value the impact of animal welfare practices on cost price in 2009 and 2013. On the operational costs, only four out of eight CAs replied: two considered the impact was positive in both years and two considered that the impact was negative.

On mortality during transport, only Denmark out of eight CAs replied that it had data on mortality during transport (loading until unloading) from 2009 and/or 2013. Article 8 of Council Directive 2006/88/EC[31] states that Member States shall ensure that when aquaculture animals are transported, transporters keep a record of mortality during transport, as practicable for the type of transport and the species transported. Denmark indeed explained that the operator or transporter has to register mortality during transport, and that these data may be controlled in connection with competent authority controls. In general CAs do not have mortality data, and these data must be collected by the business operators.

On the estimation of public concern, Table 14 shows some differences between the view of the industry and that of the CAs, with the exception of Denmark, where both the CA and industry note a decrease in public concern for fish welfare.

Table 14: EEA CA and industry evaluations of changes in public concern regarding animal welfare of farmed fish from 2009 to 2013

EEA State	Has public concern increased between 2009 and 2013?	
	Competent authority	Industry Representatives
NO	Yes	-
UK	No	Yes
IE	-	No
PL	Yes	-
CZ	Yes	-
DE	-	-
DK	No, decreased	No or No, decreased
FR	-	Yes
IT	No	Yes
GR	No	No
ES	No	No

Source: On-line survey

-: No response received/No response for this question

3.1.1.2. Industry representatives

Responses from industry representatives to the on-line questionnaire were few and disappointing. Only eight replies were received from 75 questionnaires sent, and the responses were largely incomplete. This may be explained by lack of time, as was perceived during the targeted interviews, or lack of available information. This was mitigated by contacting and interviewing industry representatives, farmed fish experts, auditors and inspectors in different countries, and fish producers directly for completion and further validation of information.

One aspect relevant to the responses of industry representatives in the on-line survey can be highlighted: the estimate of private standards. As illustrated in Table 15, in four EEA States there is an increase of the market share reported for private standards.

[31] Council Directive 2006/88/EC (2006) on animal health requirements for aquaculture animals and products thereof, and on the prevention and control of certain diseases in aquatic animals.

Table 15: Estimate of private standards market share

EEA State	Respondents and species	Estimated market share of private standards		
		2009	2013	Today
NO	-	-	-	-
UK	1 (Scottish Salmon Producers Organisation)	100%	100%	100%
IE	1 (Salmon producer) *	Don't know	Don't know	Don't know
PL	-	-	-	-
CZ	-	-	-	-
DE	-	-	-	-
DK	2 (1 producer and 1 producers' organisation)*	0%	0%	40%
FR	1 (producer organisation)*	Organic: 5% Producer association standard: 50%	Organic: 6% Producer association standard: 70%	Organic: 7% Producer association standard: 70%
IT	1 (Italian Fish Farmers Association)	50%	60%	70%
GR	1 (Sea bass/sea bream producer) *	0%	10%	65%
ES	-	-	-	-

Source: On-line survey

- No response received/No response for this question

** Anonymity required*

3.1.1.3. NGOs

There are very few animal welfare organisations active for fish welfare. However, six responses were received of which four questionnaires were completed from eight invited NGOs. The results of the NGO questionnaires were used for triangulation of the findings from the questionnaires and interviews with other stakeholders. Noteworthy contributions were those from Compassion in World Farming (CIWF), Eurogroup for Animals, RSCPA and FairFish.

3.1.2. Stakeholder consultation – targeted interviews

Due to the disappointing results from the online survey, more emphasis was put on the targeted interviews. Concerning the industry responses, generally more information was obtained on the welfare practices than on financial aspects. Most industry representatives did not want to disclose financial data, as these were considered confidential and there were concerns about the presentation of such data in a report for the Commission. A second reason was that in company book keeping, there seemed to be little data on transport costs, or costs for stunning and killing.

On many occasions, if transport occurs, it is done by nets, pumps, or trucks already present on the farm and no costs are specifically attributed. Therefore – in consultation with focus group members – we adopted a strategy in cases where costs were insufficiently obtained from industry representatives to estimate costs for transport, and for stunning and killing, based on costs of relevant equipment obtained from equipment manufacturers. The costs were allocated on the basis of the information obtained from industry representatives on the transport, and stunning and killing practices used. The results are presented in chapter 11.

3.1.3. Focus groups

The views of the focus groups were obtained by consulting individual members when developing the questionnaires and interview templates, as well as during the preliminary analysis of results for the Inception Report. These consultations have resulted in amendments to proposed questions, and additional information on transport or stunning/killing practices that were used subsequently for the evaluation of results and for the analysis.

4. Review of the literature

It should be noted that data presented in chapter 4 may differ from data presented in chapter 8. Data for chapter 8 were obtained in targeted interviews and from the four focus groups. The comprehensive literature search (see Annex IV), which was used to obtain data for chapter 4, did not provide information on all current transport and slaughter practices for the selected countries and fish species.

4.1. Transport of fish in European aquaculture

Animal transportation means the movement of animals affected by one or more means of transport and the related operations, including loading, unloading, transfer and rest, until the unloading of the animals at the place of destination is completed (Council Regulation (EC) No 1/2005). Transport of live fish of aquaculture falls under this Regulation. However, the logbook and the navigation system are not required for long journeys by road, as well as the Certificate of Competence for drivers and guardians. For terrestrial farm animals, transport is prescribed in detail in the Regulation, but not for fish.

During transport, fish are exposed to a multitude of stressors such as density changes, handling stress, water movement, noise and vibrations and poor water conditions (Dalla Villa *et al*., 2009; Sampaio and Freire, 2016). Exposure to such stressors simultaneously or in rapid succession may induce severe physiological stress (McEwen and Wingfield 2003; Koolhaas, Bartolomucci et al. 2011). In addition, the process of transport may also lead to pain and fear in fish.

Among fish species there is great variation in their oxygen, pH, salinity and temperature requirements and – more importantly in relation to transport stresses – in the range of variance they can survive. Common carp, for example, can survive low levels of oxygen and suspended solids that would be unacceptable to salmonids. Thus, each species has its own requirements for safe transportation. As a consequence, it is extremely difficult to generalise in defining optimal conditions around which legislation or codes of practice should be formulated (EFSA, 2004).

The three main methods used to transport fish are: road transport, sea transport and air transport. It should be noted that most marketable sea bream and sea bass are killed at the farm by transferring live fish from the cages to tubs with a slurry of ice and sea water in a harvest boat (EFSA, 2009) and therefore no transport methods are listed for these species in Table 17.

The transportation element of this study is limited to: a) sea bream and sea bass fingerlings/juveniles, and smolts for Atlantic salmon that are transported to on-growing installations, and; b) marketable Atlantic salmon, freshwater rainbow trout and common carp that are transported to a facility for slaughter after on-growing.

Overviews of transport methods used in Europe for fry, fingerlings or smolts to a facility for on-growing, and for marketable fish to a facility for slaughter are presented in Table 16 and Table 17, respectively. Some of the advantages and disadvantages of the transport methods are depicted in these tables.

- Road transport - Road transport is a frequent method of transferring fish from a farm with pre on-growing facilities to a farm dedicated to on-growing. Also, for example in Poland, common carp may be transported to markets where they are offered alive for sale (Lambooij et al., 2007). In Europe, common carp are also transported to facilities for slaughter. For road transport, flatbed lorries are used to transport tanks with fish. The water in these tanks is aerated with compressed air and oxygen to remove carbon dioxide and avoid hypoxia, respectively. Closed tanks may pose a problem, as carbon dioxide and TAN (total ammonia nitrogen) accumulate in the water (Dalla Villa et al., 2009).

- Sea transport – In well-boats the sea water quality is maintained at a high level by continuously pumping in or recirculating sea water. Well-boats are also used for transporting marketable salmon to a facility for slaughter (Iversen *et al.*, 2005). For transfer of salmon smolts to sea cages for on-growing (Dalla Villa *et al.*, 2009), well-boats are used.
- Air transport - To move salmon smolts over small distances, helicopters may be used. These fish are densely stocked in an open bin containing highly oxygenated water carried underneath the helicopter.

Table 16. Overview of transport methods used for transfer of Atlantic salmon and sea bass/sea bream to a farm for on-growing - advantages and disadvantages

Fish species	Transport method	Advantages	Disadvantages
Atlantic salmon	Well-boat	- Fish may recover from loading when the ship sails.	- Loading and unloading are stressful.
	Helicopter	- A fast method to transfer fish	- Stressful method of transport. - Loading and unloading of the bin are stressful.
	Transport by truck	- Flexibility with regard to planning of transport	- Water quality may deteriorate with rough driving
Sea bass/ sea bream	Transport by truck	- Flexibility with regard to planning of transport	- Water quality may deteriorate with rough driving. - Loading and unloading are stressful
	Well-boat	- Fish may recover from loading when the ship sails	- Loading and unloading are stressful

Table 17. Overview of transport methods used for transfer of Atlantic salmon, common carp, rainbow trout, sea bass and sea bream to an abattoir for slaughter - advantages and disadvantages

Fish species	Transport	Advantages	Disadvantages
Atlantic salmon	Well-boat	Fish may recover from loading when the ship sails.	- Loading and unloading are stressful. - At a facility for slaughter a waiting period of two days may be needed.
Common carp	Road transport	Flexibility with regard to planning of transport	- Water quality may deteriorate with rough driving. - Loading and unloading are stressful
Rainbow trout	Road transport	Flexibility with regard to planning of transport	- Water quality may deteriorate with rough driving. - Loading and unloading are stressful
Sea bass / sea bream	NA*	NA*	NA*

*NA = not applicable, in most cases sea bass/sea bream are not transported to a facility of slaughter

As it is known that transport may expose fish to an accumulation of stressors, planning the process beforehand, preparing the fish and transport vehicle, and the availability of well-trained staff are prerequisites. Practical experience and reported studies show it is essential that loading (and also unloading) fish into the transport tanks of a truck, or a large tank that is carried by helicopter to transport smolts, or a well-boat should be made as stress-free as possible. A helicopter may still be used for short distance transfers of fish to on growing sites in the UK. Fish are loaded from trucks into a tank slung beneath a helicopter. Subsequently, the tank is sealed and flown to the sea cages. The tank is lowered into the water of a sea cage and the fish are released.

Stress in fish should be minimised, as the process of transport may result in a higher metabolic rate in fish and induce shedding of mucus by the fish, leading to a deterioration of the quality of the water. Another relevant factor is the interaction between man and animal. Poorly managed crowding, loading or unloading fish may also lead to severe injuries, increase aggression among fish or even result in a higher mortality.

A handling method such as dry netting of large batches of fish should be avoided; the use of a fish pump is preferred. However, the use of a fish pump should not lead to super-saturation of the water with nitrogen gas in a well-boat. This hazard can be avoided by degassing water in live haul before loading fish (Rosten and Kristensen, 2011). Degassers for water, carbon dioxide and nitrogen are not standard equipment in all vessels, but are common on vessels specialised in closed transport (VKM, 2008).

It is essential to ensure that sufficient staff are available to make loading and unloading a smooth and quick operation, thereby minimising delays and the total time that the fish are in the tanks of a truck or well-boat. Regarding density of fish during transport, the deterioration of water quality is the overriding factor, so the journey length; the size, life stage and species of fish; and the question whether the system used is open or closed will all determine densities. In a closed system, carbon dioxide (King, 2009) and ammonia – which are both excreted by fish – will increase during transport. Oxygen needs to be administered to avoid hypoxia.

Transport methods used for the selected fish species in the case-study EEA States have been evaluated to assess whether the relevant OIE standards are met. Further information is presented and discussed in section 8.2 and chapter 10.

4.2. STUNNING AND KILLING OF FISH IN EUROPEAN AQUACULTURE

At present the protection of farmed fish at the time of killing falls with the scope of Council Regulation (EC) No 1099/2009 on the protection of animals at the time of killing, which covers all vertebrate animals. However, as regards fish, only the general requirements for killing and related operations shall apply. The Regulation specifies that animals should be spared any avoidable excitement, pain or suffering during transport, lairage (a place where live animals are kept temporarily), restraining, stunning, slaughter or killing. In Council Regulation (EC) No. 1099/2009 it is stated that *Member States may maintain or adopt national rules regarding the protection of fish at the time of slaughter or killing and shall inform the Commission thereof*.

It should be noted that live chilling of Atlantic salmon is used to calm fish prior to stunning (EFSA, 2009a). As it is not a stunning method for this fish species, live chilling of Atlantic salmon will not be presented in this section.

Specific definitions used in this proposal are presented below (Van de Vis et al., 2014):

- Insensible: Inability to perceive (and as a consequence respond to) stimuli.
- Slaughter: The killing of animals, especially farmed ones, for the production of food. Killing is defined in Council Regulation (EC) No. 1099/2009 as any intentionally induced process which causes the death of an animal;
- ‘Stunning’ means any intentionally induced process which causes loss of consciousness and sensibility without pain, including any process resulting in instantaneous death. When stunning is reversible it should be followed by the application of a killing method. In case of an irreversible stun, the application of a method also induces death.

- Unconsciousness: A state of unawareness (loss of consciousness) in which the brain is unable to process sensory input (e.g., during (deep) sleep, anaesthesia or due to temporary or permanent damage to brain function).

An overview of the published literature on stunning, stunning/killing and killing methods used for the selected species is presented in Table 18. The advantages and disadvantages of these methods are briefly described. Further information is provided in the following paragraphs.

Table 18. Overview of methods used for stunning, stunning/killing and killing – advantages and disadvantages

Stunning or stunning/killing	Fish species	Advantage	Disadvantage
Electrical stunning	Atlantic salmon Rainbow trout Carp	- An immediate stun can be achieved; - Product quality can be affected, mis-stuns* may occur due to varying resistance between fish; - Allows pre-rigor filleting.	- Effective killing method is needed; - Carcass damage can occur.
CO_2 stunning	Rainbow trout		- Very stressful
Percussion	Atlantic salmon	- An immediate stun can be achieved; - When applied correctly, no recovery; - Allows pre-rigor filleting.	- Mis-stuns due to variation in size; - Damage to the head can occur.
	Common carp	- When applied correctly, no recovery.	- Manual application can lead to mis-stuns; - Damage to the head can occur
	Rainbow trout	- When applied correctly, no recovery.	- Manual application can lead to mis-stuns.
Live chilling with CO_2	Atlantic salmon	Slow onset *of rigor mortis* allows pre-rigor filleting.	- Fish are not stunned. - Method is stressful.
Asphyxia in ice or ice water	Sea bass Sea bream Rainbow trout	- Easy to use; - Food quality and safety.	- Stress in fish due to steep drop in temperature.

* A mis-stun occurs when the application of a stunning method is not effective. For electrical and percussive stunning this implies that consciousness is not lost immediately.

As a distinction can be made among methods for stunning, stunning/killing and killing, these methods are described separately in the following bullet points. Further information on practices at slaughter is presented in sections 8.1, 8.3 and 10.5.2. Information on equipment is presented in section 7.1.

Methods used for reversible stunning

- <u>Electrical stunning (Atlantic salmon, rainbow trout, common carp)</u>
  There are two approaches to electrical stunning applicable for use in practice. The current is applied to the whole-body of fish. For welfare reasons, the application of electricity should

result in immediate (within 1 second) loss of consciousness and sensibility. When a stun is not immediate, the application of electricity can be painful (for a review on pain in fish see Braithwaite and Ebbesson, 2014).

The fish species can either be stunned in water or after removal from the water.

Stunning in water, which is used for sea bass in a laboratory setting (as reviewed by Lines and Spence, 2014) and for rainbow trout (Lines and Spence, 2014; EFSA, 2009b) and carp in practice (EFSA, 2009d), involves exposing the fish to an electrical field. For rainbow trout the electrical field is created by using two plate electrodes in a water tank or ring or plate electrodes in a pipe through which water is pumped (EFSA, 2009b), whereas electrical stunning of carp is performed by using two plate electrodes that cover the whole area of two opposite walls or two rod electrodes mounted in a manual device (EFSA, 2009d).

For stunning after removing out of water, which is used for Atlantic salmon (EFSA, 2009c), the fish is placed in a device (for example, a conveyer belt) as negative electrode with steel flaps suspended (Figure 1). The rows of steel flaps are the positive electrodes.

In principle, electrical stunning in water may be less stressful to a fish, as for electrical stunning after dewatering fish are exposed to air (Lambooij, 2014).

Figure 1: Electrical stunning after dewatering: Atlantic salmon leaving the electrical stunner

Several studies show that fish can only be stunned by the use of electricity but not killed, as the fibrillation of the heart is not permanent. In case of a permanent fibrillation the supply of oxygen to the brains is affected and the animal dies from lack of oxygen in the brains. Hence, for fish, electrical stunning needs to be followed by a killing method, e.g. chilling of unconscious fish in ice water or percussion (Van de Vis et al., 2014).

- <u>Carbon dioxide stunning (Rainbow trout):</u>
  Using carbon dioxide stunning of Atlantic salmon, Robb et al (2000) reported a slow induction of unconsciousness and insensibility combined with vigorous escape attempts by fish during the induction period. For this reason, the use of carbon dioxide has been prohibited in Norway (Anonymous, 2006), and it is also not used in the UK. In practice, carbon dioxide is bubbled into a tank filled with seawater until a pH level of about 5.5 - 6.0 is obtained. This corresponds to CO_2 levels of 200 - 450 mgl/1. Fish are transferred to the water and after an exposure of 2-4 minutes the struggling stops. Subsequently, the fish are removed and bled. The method is used for rainbow trout (EFSA, 2009b).

Methods used for irreversible stunning

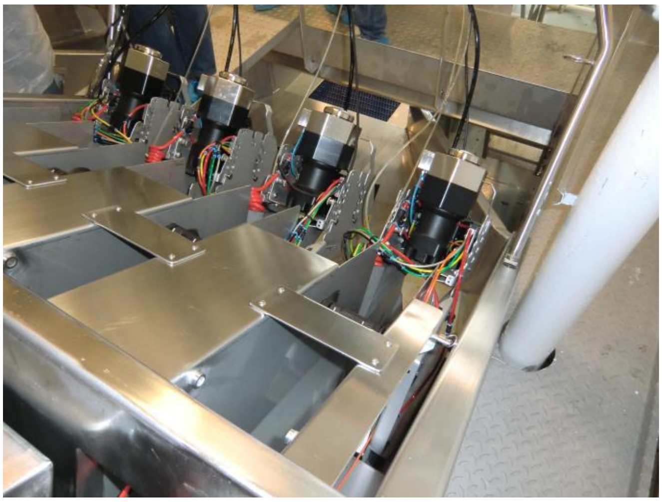
- Percussion (Atlantic salmon, rainbow trout, common carp)

  Percussive stunning is the application of a blow to the head manually or by using a device (EFSA, 2009c). A blow to the head is painful when the stun is not achieved immediately. Percussive stunning should, therefore, result in an immediate stun (within one second) and recovery should not occur.

  It has been reported that percussed Atlantic salmon die of cerebral haemorrhage (Lambooij et al., 2010). Hence, percussion is an irreversible stunning method, in contrast to electrical stunning, from which a fish recovers when a killing method is not subsequently applied. Percussion cannot be applied with all fish species. For example, percussion is not effective for European eels (Van de Vis and Lambooij, 2006), yellowtail kingfish and African catfish.

  At commercial slaughterhouses for Atlantic salmon, an automatic device (Figure 2) is commonly used to apply a blow to the head. Prior to its application the fish are removed from the water. The main hazard for automated percussive stunning is variation in the size of fish within the population causing a mis-stun in some fish. Machines for stunning and killing salmon should not be used if fish may be injured, or not stunned immediately because of their size or orientation in the machine. For percussive machines, size adjustment of the machines should be done by skilled personnel, as it is crucial for stunning efficiency.

Figure 2: A percussive stunner for Atlantic salmon



Percussive stunning uses a non-penetrating bolt driven by air pressure. The bolt should be fired mid-dorsally on the skull, slightly dorsal of the eyes. The salmon slide down the chute and when the snout of the salmon hits a switch, the bolt is fired.

For carp, the current stunning method consists of a blow or repeated blows on the head with a priest (a mallet used to stun and kill fish) (Lambooij et al., 2007). Under field conditions, carp are exposed to air for 10-30 minutes before the application of the blow to the head by hand (EFSA, 2009d; Van de Vis et al., 2006, expert interviews). It should be noted that air exposure for 10-30 minutes is stressful for carp, as the animal is lying on its side in a dry tank possibly covered by other carp that are also attempting to escape.

Percussion of rainbow trout is performed manually.

Killing methods without stunning

- Live chilling with carbon dioxide (Atlantic salmon)

  Exposure of Atlantic salmon to live chilling with carbon dioxide is a recently developed method. It is likely that its application does not result in loss of consciousness (Erikson, 2011).

The salmon is exposed to a temperature of -0.5 to 3 °C with added carbon dioxide at low and moderate levels (65-257 mg/l) and oxygen to levels of 70-100 % saturation (Erikson et al., 2006). The water is re-used. Subsequently, the fish are killed by gill cutting and bled in chilled sea water. An evaluation of live chilling with carbon dioxide showed that the use of carbon dioxide in combination with live chilling was found to be stressful, as the fish showed aversive reactions (Erikson, 2011).

- Asphyxia in ice or a slurry of ice and sea water (sea bass, sea bream and rainbow trout)
  Asphyxia in ice or a slurry of ice and sea water involves a transfer of sea bass and sea bream from the sea water cage or tank to ice flakes or ice water slurry (in a ratio ranging from 1:2 to 3:1) (EFSA, 2009a).

  Asphyxia in a slurry of ice and sea water is most commonly used for sea bass and sea bream (EFSA, 2009a). The temperature of the slurry fluctuates from 0 to 2 °C. In case of asphyxia in air sea bass and sea bream are removed from the water and placed in free-draining bins or boxes (EFSA, 2009a). This method is stressful for sea bass, sea bream and trout, as aversive responses in behaviour were observed in the conscious animals (Robb and Kestin, 2002). For rainbow trout the method is similar – the fish are transferred into a slurry of ice and fresh water (EFSA, 2009b).

5. REVIEW OF NATIONAL LEGISLATION

Council Regulation (EC) No 1/2005 on the protection of animals during transport and related operations applies to the welfare of farmed fish during transport. Farmed fish are also covered by Council Regulation (EC) No 1099/2009 on the protection of animals at the time of killing, although without the provision of specific rules. However, Article 27(1) of Regulation 1099/2009 allows Member States to maintain or adopt national rules regarding the protection of fish at the time of slaughter or killing, but requires them to inform the Commission thereof.

It is also worth mentioning in relation to fish welfare that Article 8 of Council Directive 2006/88/EC[32] states that Member States shall ensure that when aquaculture animals are transported, transporters keep a record of mortality during transport, as practicable for the type of transport and the species transported.

In the targeted questionnaire, EEA CAs were asked if they had fully implemented Regulation (EC) No 1/2005 and Regulation (EC) No 1099/2009, and if any additional national guidelines or national rules were subsequently introduced concerning the implementation of the Regulations. Although EEA CAs generally indicated that the Regulations were fully implemented, this could not always be confirmed by audit reports.

In the UK, this could be confirmed because the Animal Welfare Act 2006 in England and Wales, and the Animal Health and Welfare (Scotland) Act 2006, provide farmed fish with protection against unnecessary suffering and place a duty of care on the person responsible for the fish to ensure their needs are met.

For Poland, in the absence of specific legal requirements on slaughter methods, competent authorities and stakeholders have agreed and issued guidelines to protect animal welfare of carp during the harvest season. These guidelines aim to alter traditional consumer behaviour in a direction that is beneficial for carp welfare.

For Spain, no national or Spanish autonomous community (AC) legislation was identified on the slaughter of aquaculture animals concerning Article 3(1) of Regulation (EC) No 1099/2009, which requires that animals shall be spared any avoidable pain, distress or suffering during their killing and related operations.

In Italy, in 2015 it was found that there was no national or regional legislation covering the slaughter of aquaculture animals concerning Article 3(1) of Regulation (EC) No 1099/2009. In the same audit, animal welfare relating to slaughter was not included in the inspections in the regions visited. In relation to Directive 2006/88/EC (on animal health requirements for aquaculture animals and products thereof, and on the prevention and control of certain diseases in aquatic animals), this Regulation is not always implemented. As noted in the FVO audit report in 2015 for Italy, transporters of animals are registered and officially controlled according to established procedures as regards animal welfare rules. However, procedures have not been developed for official verification as to whether transporters of live fish keep records (e.g. mortality during transport or records of the farms and processing establishment which have been visited by the transport, or the location of water exchanges during transport) as required in Point 3, Article 8, Chapter II of Directive 2006/88/EC.

As both EU measures are regulations, they enter into force when the EU Regulations enter into force. In most countries, additional good practice or guidance documents are available. However, these are not binding.

[32] Council Directive 2006/88/EC on animal health requirements for aquaculture animals and products thereof, and on the prevention and control of certain diseases in aquatic animals

In addition, private standards are implemented in the fish farming sector. The industry has widely developed and adopted its own standards on fish welfare. These are reviewed under Private Standards (see chapter 6). In Table 19, the implementation of Regulation (EC) No 1/2005 and Regulation (EC) No 1099/2009 in the case study countries is presented, with national guidelines or codes of practices that regulate welfare aspects of transport and slaughter of farmed fish.

Table 19: National legislation and national guidelines or codes of practices that regulate welfare aspects of transport and slaughter of farmed fish

Country	National Legislation	National guidelines or practices
NO	– Regulation (EC) No 1/2005 not fully implemented (CA survey). – Regulation (EC) No 1099/2009 on the protection of animals at the time of killing fully implemented – Commission Regulation (EC) No 1250/2008 as regards certification requirements for import of fishery products, live bivalve molluscs, echinoderms, tunicates and marine gastropods intended for human consumption sets rules for general fish welfare requirements, competence of operators, methods and technical devices, handling, stunning and killing. Fish has been included in the scope of the Norwegian Animal Welfare Act that entered into force 1 January 2010	– A comprehensive guidance document has been prepared for the industry by the Norwegian Food Safety Authority (NFSA) regarding requirements for good aquaculture animal welfare during slaughter
UK	– Regulation (EC) No 1/2005 and Regulation (EC) No 1099/2009 fully implemented – Animal Welfare Act 2006 – Animal Health and Welfare (Scotland) – The Welfare of Animals (Transport) (England) Order 2006 (and equivalent legislation in Scotland and Wales)	– Opinion on welfare of farmed fish; Farm Animal Welfare Committee; 2014 – Code of good practices[33]
IE	– Animal Health and Welfare Bill 2012	– A Fish Health Code of Practice for Salmonid Aquaculture in Ireland (2014) – The Farmed Salmonid Health Handbook (2011)[34]
PL	– Regulation (EC) No 1/2005 fully implemented – Regulation (EC) No 1099/2009 on the protection of animals at the time of killing not fully implemented (CA survey) – Animal Protection Act, (OJ No 111, Item 724; of 1998 No 106, Item 668)	– Code of Good Practice (Kodeks Dobrej Praktyki); 2014
CZ	– Regulation (EC) No 1/2005 and Regulation (EC) No 1099/2009 fully implemented – Act No 246/1992 Coll. and following amendments on the protection of animals against cruelty – Decree No 245/1996 Coll. on stunning/killing	– Guideline No. 5/2015 on stall selling fish / sales places

[33] http://thecodeofgoodpractice.co.uk/chapters/

[34] http://www.fishhealth.ie/FHU/sites/default/files/FHU_Files/Documents/FarmedSalmonidHealthHandbookOctober2011.pdf

Country	National Legislation	National guidelines or practices
	methods – Decree No 382/2004 Coll. on stunning/killing methods – Act No 99/2004 on fish pond management, incl for fish farming	
DE	– Regulation (EC) No 1/2005 and Regulation (EC) No 1099/2009 fully implemented – Law for protection of animals during transport (Verordnung zum Schutz von Tieren beim Transport und zur Durchführung der Verordnung (EG) Nr. 1/2005 des Rates (Tierschutztransportverordnung -TierSchTrV) – Law for protection of animals related to killing and slaughter (Verordnung zum Schutz von Tieren im Zusammenhang mit der Schlachtung oder Tötung und zur Durchführung der Verordnung (EG) Nr. 1099/2009 des Rates (Tierschutz-Schlachtverordnung -TierSchlV)	– Good Hygienic practice (1994) (Verordnung über die hygienischen Anforderungen an Fischereierzeugnisse) – Good Practice in pond farming (carp) (gute fachliche Praxis der Teichwirtschaft in Brandenburg) – Practical and legal aspects of fish transport (Praktische und Rechtliche Aspekte beim Fischtransport (Bayerische Landesanstalt für Landwirtschaft (LfL; 2013)
DK	– Regulation (EC) No 1/2005 and Regulation (EC) No 1099/2009 fully implemented – Order of protection of animals under transport (Bekendtgørelse om beskyttelse af dyr under transport; BEK nr 1729 af 21/12/2006)	– None (CA survey)
FR	– Note de service 2007-8016 de la DGAL du 16 janvier 2007 (DGAL/SDSPA/N2007-8192) – Rules for transport of fish and products thereof on in the country (Règles applicables au transport de poissons vivants et de leurs produits sur le territoire national; DGAL/SDSPA/2016-955; 2016)	– *(no CA response received)*
IT	– Regulation (EC) No 1/2005 and Regulation (EC) No 1099/2009 fully implemented (CA survey)	– None (CA survey)
GR	– Regulation (EC) No 1/2005 and Regulation (EC) No 1099/2009 fully implemented (CA survey)	– Circular on fish transport (19/5/2015) – 2 Circulars on welfare of farmed fish (23/3/2015; 9/6/2015)
ES	– Regulation (EC) No 1/2005 and Regulation (EC) No 1099/2009 fully implemented – Animal Transportation Law (Legislación de protección de los animales en el transporte)	– Code of practice for killing of fish (Piscicultura; Guia de practica correctas para el sacrificio; 2016; AEONOR

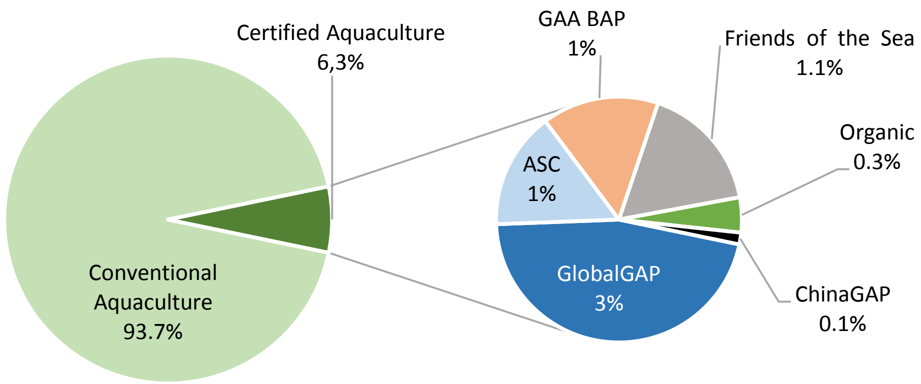
The legislation, and national guidelines or codes of practices that regulate welfare aspects of transport and slaughter of farmed fish are not as developed for the fish sector as for farm animals (cattle, pigs and poultry)(Farm Animal Welfare Committee; 2014). However, in recent years, specific measures are increasingly published (CZ, DE, ES GR, PL, UK) which illustrates growing attention in several EU Member States for fish welfare.

6. Review of private standards

6.1. Introduction

The industry has adopted a number of codes of practices and quality schemes that include measures to safeguard fish welfare. Voluntary international private standards, such as GlobalGAP, Aquaculture Stewardship Council (ASC), Global Aquaculture Alliance Best Aquaculture Practices (GAA BAP), organic standards (Naturland) and RSPCA's ethical food label address animal welfare during production, during transport and at slaughter at different levels. Certification of these standards is based on independent farm audits carried out by a third-party certification body.

Figure 3. Certified aquaculture as a proportion of total global production



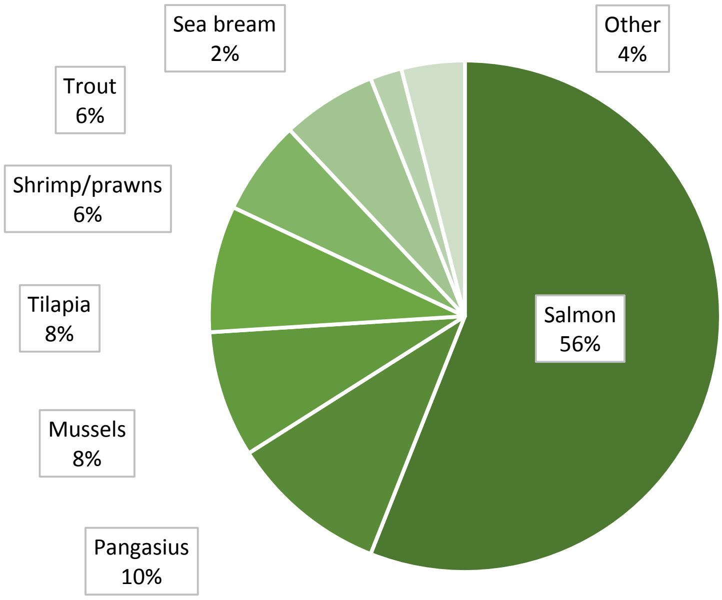
Source: State of Sustainability Initiatives Review: Standards and the Blue Economy, 2016, J. Potts. A Wilkins, M. Lynch, S. McFatridge
http://www.iisd.org/sites/default/files/publications/ssi-blue-economy-2016.pdf

Certification in aquaculture is growing rapidly , especially with the introduction of the ASC standard. In 2015, certified aquaculture products accounted for just over 6 % of total aquaculture production, with GlobalGAP accounting for almost half (Potts et al., 2016).

Certified aquaculture includes a limited number of species with high commercial value. In 2015, salmon accounted for 56 % of the global certified total. Also, pangasius, tilapia, trout and sea bream are important species groups.

In contrast, carp is the most widely produced aquaculture species group, accounting for 39 % of global production, but has no significant certified volume. Global demand for sustainable seafood is driven almost entirely by Europe, North America and Japan.

Figure 4. Certified global aquaculture production, 2015



Source: State of Sustainability Initiatives Review: Standards and the Blue Economy, 2016, J. Potts. A Wilkins, M. Lynch, S. McFatridge
http://www.iisd.org/sites/default/files/publications/ssi-blue-economy-2016.pdf

6.2. INTERNATIONAL PRIVATE STANDARDS

This part of the study provides a review of international private standards, best practices and voluntary assurance schemes covering current fish welfare practices during transport and at slaughter. This starts with a determination of today's market share of private standards. However, not all data could be reported as some are confidential and need to be approved by the providers prior to publication.

Terrestrial farm animal welfare has attracted considerable attention in recent times. However, fish welfare during transport and at slaughter is only addressed by a very limited number of international private standards. Growing concern and interest in farm animal rearing conditions – together with social and environmental issues – indicate that animal welfare will continue to increase in importance in discussions about animal production and product quality. It is expected that animal welfare will gradually become more important; however, significant changes are not expected in the short-term (one or two years).

A comparison between the OIE international standards and the major (international) private standards shows that fish welfare during transport and at slaughter is predominantly implemented in the salmon sector, to a lesser extent in trout production and on a limited scale in sea bass and sea bream production. A very limited number of carp farms implement good welfare practices through private standard assurance systems.

GlobalGAP

GlobalGAP is a private sector body that sets voluntary standards, or Good Agricultural Practices (GAP), for the certification of farmed products – including finfish, crustaceans and molluscs – around the globe. GlobalGAP began as EUREPGAP in 1997 as an initiative by retailers from the EuroRetailer Produce Working Group (EUREP). British retailers in conjunction with supermarkets in continental Europe were the key players in developing the standards in response to the growing concerns of consumers about their food in relation to safety, animal welfare, and environmental and social impacts. Over the next ten years, EUREPGAP gained in global significance and was re-branded as GlobalGAP in 2007.

The certification started as a business to business guarantee, but recently a consumer logo was introduced. The standard covers the entire production chain from brood stock, seedlings and feed suppliers to farming, harvesting and processing. GlobalGAP is the only international private standard outside the UK that covers animal welfare practices at harvest and slaughter. Although the inspection procedure does not include direct assessment of fish welfare (i.e. examination of fish), the GlobalGAP standard is close to the fish welfare standards set by the OIE.

In 2015/2016, around 75 % and 85 % of Atlantic salmon were certified for Norway and UK, respectively. These rates are increasing while around 25 % of Atlantic salmon in Chile is certified for GlobalGAP.

Aquaculture Stewardship Council (ASC)

The Aquaculture Stewardship Council (ASC) is as an independent, not-for-profit organisation co-funded by the World Wildlife Fund (WWF) and the Dutch Sustainable Trade Initiative (IDH) in 2010. ASC aims to become the world's leading certification and labelling programme for responsibly farmed seafood. Certification is through an independent third-party process and reports are uploaded to the public ASC website. ASC certified products may bear the ASC logo.

The ASC standards are still species-specific and cover salmon, freshwater trout, tilapia spp., pangasius spp., cobia and seriola spp. and various farmed invertebrate species. Carp, sea bream and sea bass are not covered in the ASC standards yet. This will change in future as ASC is working on a general fish standard.

The focus of ASC standards is on the environmental and social impacts of aquaculture. Animal welfare is only included indirectly. The focus of the standard is on production and the immediate inputs to production. Transportation, stunning and killing are not explicitly included in the scope.

The salmon standard requires evidence of adherence with the OIE Aquatic Animal Health Code (indicator 5.3.4). However, this is not a specific requirement in the freshwater trout standard. The unit of certification is a farming site. Animal welfare during transport and at slaughter are not covered.

GAA – Best Aquaculture Practices (BAP)

Best Aquaculture Practices (BAP) is an international certification programme based on performance standards for the entire aquaculture supply chain: farms, hatcheries, processing plants and feed mills. BAP certification is based on independent audits, which evaluate adherence with the BAP standards developed by the Global Aquaculture Alliance (GAA). The BAP standards currently cover salmon, tilapia spp., pangasius spp. and channel catfish (Ictalurus punctatus), as well as carp and various other (primarily marine) species. Although predominantly focusing on environmental responsibility, BAP certification standards cover the key elements of responsible aquaculture, including social responsibility, food safety, animal health and welfare, and traceability.

The animal welfare component is most comprehensively covered in the salmon standard, but it is less well covered in the general finfish and crustacean farms standard, which is applicable to all other species (BBFAW, 2016). Therefore, the BAP standard provides only very brief requirements on finfish welfare. Certified farms do not necessarily need to fulfil the OIE requirements.

RSPCA Assured

RSPCA (Royal Society for the Prevention of Cruelty to Animals) Assured – previously Freedom Food – is a UK ethical food label dedicated to farm animal welfare. RSPCA Assured has two finfish aquaculture standards covering Atlantic salmon (*Salmo salar*) and rainbow trout (*Oncorhynchus mykiss*). These cover a high level of fish welfare. RSPCA is not strictly a global standard, however, farmed European salmon is significant in global trade.

RSPCA is recognised as the only scheme in Europe dedicated to farm animal welfare and has been acknowledged as a higher-level scheme by the UK government. Unlike other schemes, it is completely independent from the food and farming industries. The RSPCA's welfare standards are written by its team of scientific officers in the Farm Animals Department and are based on leading scientific, veterinary and practical industry expertise.

The RSPCA Assured scheme (Freedom Food) is implemented for 78 % of Scottish farmed salmon (RSPCA, 2015).

Other (UK) Farm Assurance Schemes and Codes

The UK is a world leader in the campaign for enhanced farmed fish welfare. Several UK entities have developed guidelines for humane slaughter of farmed fish. UK aquaculture industries and some grocery retailers have adopted these guidelines.

Besides the RSPCA, other non-governmental animal welfare organisations include the Scottish Society For The Prevention Of Cruelty To Animals (SSPCA), the Farm Animal Welfare Council (FAWC) and the Humane Slaughter Association (HAS).

In the UK, all key supermarkets have reportedly adopted humane slaughter standards for salmon and trout. RSPCA Assured and the Code of Good Practice for Scottish Finfish Aquaculture (CoGP) are UK farm assurance schemes covering fish and both require humane slaughter methods to be used.

The aquaculture/retail industry in the rest of Europe and the world has been slower to respond to similar guidelines.

The major UK retailers, such as Morrisons and Tesco, have adopted fish welfare guidelines that aim to reduce stress, suffering and pain. The UK farmed fish slaughter standards include:

- Fish should not be out of water for longer than 15 seconds
- Stunning must occur in less than one second
- If fish are to be slaughtered using a two-phase method, unconsciousness must be long enough to ensure fish are dead before potential recovery
- Dry electrical stunning is not allowed in RSPCA guidelines

Eurogroup for Animals is the European animal advocacy organisation and campaigns for the development and enforcement of higher animal welfare standards in food and farming, both through EU legislation and through the voluntary means of responsible food chain actors. This group puts forward aspects such as humane methods of stunning before slaughter and regulation of fish transport in aquaculture.

Organic Farming Schemes

While organic aquaculture is relatively new and is currently limited to just a small number of countries and species, it is growing in importance. Today, organic aquaculture represents around one per cent of European aquaculture production. Over the past decade, the number of private-label organic standards and certifying bodies has grown in line with the increase in production.

Organic farming standards, such as the Soil Association (UK and Scotland) and Naturland, address ecological production mainly by biodiversity, feed ingredients and stocking density during production. Handling of fish during transport and at slaughter is only briefly addressed.

Salmon is currently the by far the leading organic species produced in Europe and accounts for 1.4 % of the total output. For organic carp, only very basic requirements are set.

Standard Benchmark Tools

The Global Sustainability Seafood Initiative (GSSI) is a global platform and partnership of seafood companies, NGOs, experts, governmental and intergovernmental organisations that created a Global

Benchmark Tool for seafood certification schemes. The FAO Code of Conduct for Responsible Fisheries (CCRF), the FAO Guidelines for Eco-labelling of Fish and Fishery Products from Marine/Inland Capture Fisheries and the FAO Technical Guidelines for Aquaculture Certification (FAO Guidelines) were used as reference documents.

GSSI's Benchmark Tool includes GSSI Essential Components that are based on the CCRF and the FAO Guidelines, and which seafood certification schemes must meet to be recognised by GSSI. GSSI has also created GSSI Supplementary Components, which allows schemes to show their diverse approach and helps stakeholders understand where differences between schemes may exist.

These GSSI Supplementary Components are grounded in the CCRF and related FAO documents, ISO normative standards and ISEAL codes.

The Business Benchmark on Farm Animal Welfare (BBFAW) is addressing animal welfare issues in aquaculture. The objective if this benchmark is not to consider every possible welfare issue in all farmed species, but to highlight the more significant issues affecting commercially important species, including transport and humane slaughter (BBFAW, 2016). BBFAW identified whether or not companies have published information on their management of welfare issues relating to finfish aquaculture (www.bbfaw.com).

Conclusion

From a private standard perspective, fish welfare is complex. Generally, the private sector has taken the lead in responding in the marketplace, while governments are working on the complex harmonisation on fish welfare definitions, measurements and production standards before establishing legislation at national and international levels. Animal welfare scientists and producer associations are using the best available information to continually establish best practices that both improve animal care and economic viability. In fish welfare, it is important to maintain knowledge from different perspectives, such as science, consumer trends, market access, standards and legislation, and supplier requirements.

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- ASC
- GAA/BAP
- FAO / IFC
- Naturland
- RSPCA - https://www.rspcaassured.org.uk/farm-animal-welfare/salmon-and-trout/
- Food and Agriculture Organization of the United Nations (FAO), the Council of Europe and the International Finance Corporation (IFC), which is part of the World Bank Group.
- GFSI - http://www.mygfsi.com/schemes-certification/benchmarking.html
- CEFAS
- Defra
- Greenpeace

- Compassion in World Farming (CIWF)
- World Society for the Protection of Animals (WSPA) -
- Guide for the Sustainable Development of Mediterranean Aquaculture
- http://www.baader.com/en/products/fish_processing/salmonides/salmon_and_seatrout/harvesting.html
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- http://www.fawc.org.uk/freedoms.htm
- http://www.bapcertification.org/bap-standards/
- http://www.bapcertification.org/wp-content/uploads/2017/01/BAP-SalmonF-1016.pdf

7. INFORMATION ON EQUIPMENT AND TRAINING

In 2009, the AHAW Panel of EFSA adopted seven species-specific opinions on the welfare aspects of stunning and killing methods for farmed fish. Species include Atlantic salmon, common carp, rainbow trout, European sea bass/gilthead sea bream, Atlantic blue fin tuna, European turbot and European eel. An overview is presented of the main equipment described in these papers. Developments in methods and equipment for harvest and slaughtering have occurred particularly in the salmon sector.

7.1. EQUIPMENT

Pumping and pumps

Farmed marketable Atlantic salmon are transferred from sea cages to a well-boat with vacuum pumps that suck water and fish into a pipe and up to a pump chamber, before compressed air pushes them out from the chamber into a new pipe that leads to the receiving unit. This type of pump is also used to transfer marketable salmon from a well-boat to a waiting cage or slaughter line. Vacuum pumps are also used to transfer marketable freshwater rainbow trout from a tank to a truck. For fry and fingerlings Matsusaka pumps are used.

Stunning equipment suppliers

Effective methods are limited to percussive and electrical stunning for most species. However, even these methods can have a poor welfare outcome. For effective stunning, equipment must be properly designed for the species in question and effectively used by well-trained staff.

It should be noted that for the design and construction of equipment for percussive and electrical stunning a close collaboration between industry and research is needed. Only four major producers of equipment of percussive and electrical stunning collaborate with research institutes. Design and construction of equipment for stunning should be based on scientific data to ensure that the use of the equipment for percussive and electrical stunning results in an immediate stun in fish. Without the use of scientific data in the design and construction of equipment for percussive and electrical stunning it is doubtful whether the use protects fish at slaughter. It appears that, other than the four major producers, manufacturers do not seem to collaborate with research institutes.

Transport on land and by well-boat

The vessels used for transporting fish will inevitably vary in age and size, and will make use of different types of equipment. Not all are suitable for closed transport. Best practice would call for the use of vessels equipped with CO_2 degassers, O_2 feedback control system, protein skimmers, a moveable bulkhead (if it is a well-boat), and a water cooling system (or protection towards external heat through isolated tanks if it is a truck), a fish surveillance system (e.g. underwater cameras), and systems for water quality monitoring (Rosten, & Kristensen, 2011). Water in a truck is oxygenated or aerated to control levels of oxygen in the water. The water in a truck may be refreshed, depending on the length of the journey. Water quality in a truck can be measured by registration of temperature and oxygen.

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– Rosten, T.W., Kristensen, T. (2011). Norwegian Institute for Water Research – an institute in the Environmental Research Alliance of Norway – Report. Best practice in live fish transport

7.2. TRAINING

Training of personnel handling fish is key for improving fish welfare. Studies show that the training of staff makes their attitude to animals more positive and improves the welfare of animals prior to and during the process of stunning. It is also recommended by EFSA[35]. However, fish possess a characteristic physiology that is very different from terrestrial animals. Furthermore, farmed fish are slaughtered and killed in a different manner and context, in particular as regards the *ante-mortem* inspection process. This is illustrated by the different EFSA opinions on the welfare at killing of different farmed fish species relevant for this study: Atlantic salmon[36], carp[37], trout[38], and sea bass/sea bream[39]. Therefore, training on fish welfare must be specifically designed for the different fish species.

For livestock, an animal welfare officer shall be designated by business operators to slaughterhouses under Regulation (EU) No 1099/2009. The Regulation requires slaughterhouse operators to appoint a qualified person – the animal welfare officer – to ensure that standard operating procedures are implemented so that animal welfare rules are properly understood and applied.

For fish, there is no such animal welfare officer. The Overview report on 'Implementation of the Rules on Finfish Aquaculture' (DG Health and Food Safety, 2015) states that most staff from Member State Competent Authorities performing official controls are trained for their area of competence as required in Article 6 of Regulation (EC) No 882/2004 and are actively involved in ongoing training. However, the main tasks for inspectors are related to other farm animals rather than fish. Consequently, they only carry out occasional visits to fish farms and it is difficult for many inspectors to recognise signs of fish diseases or to carry out *post mortem* examinations on site to investigate health problems[40]. Similarly, it can be expected that fish welfare may not be as well addressed as the welfare of livestock, and specific further training will be required.

To ascertain whether lack of knowledge is preventing the transition to methods and equipment required by OIE standards, and whether training has become more widespread in recent years, CAs in the case-study EEA States were asked if their staff had received any internal or external training sessions regarding the evaluation of fish welfare during transport and slaughter in 2009 and 2013.

Responding to the CA questionnaire: the Czech Republic, Poland and Norway CAs confirmed that their staff receives fish welfare training; Spain and UK CAs reported that they don't know, and; CAs from Denmark, Ireland and France did not respond. Fish welfare training for CA staff was reported to be less advanced than for livestock. Poland responded that no training was provided in 2009, whereas this was the case in 2013, suggesting some progress. Progress was also demonstrated by inclusion of animal welfare in inspection forms.

Based on EFTA and DG Health and Food Safety mission reports, the situation in case study countries can be summarised as follows:

[35] EFSA Journal (2004), 45, 1-29, Welfare aspects of the main systems of stunning and killing the main commercial species of animals. FSA-Q-2003-093
[36] http://onlinelibrary.wiley.com/doi/10.2903/j.efsa.2009.1011/abstract
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[39] http://onlinelibrary.wiley.com/doi/10.2903/j.efsa.2009.1010/abstract
[40] Overview report Implementation of the Rules on Finfish Aquaculture. DG Health and Food Safety 2015. doi:10.2875/634307

Norway

Staff performing official controls are appropriately trained for their area of competence, as required by Article 6 of Regulation (EC) No 882/2004. They are either trained veterinarians or aqua medicine biologists. The staff met performing the official controls demonstrated deep knowledge of animal health for aquaculture animals, and most had many years of experience and comprehensive training in the subject. In addition, more experienced staff shared knowledge with and supported new staff as part of the introduction training. According to national legislation, approved animal welfare training is compulsory for operators – both for staff working at aquaculture farms as well as for staff handling live fish at slaughterhouses, which also includes compulsory brush-up courses every five years. A comprehensive handbook for operators has been developed by industry in association with the relevant responsible official departments and agencies covering all aspects of salmon aquaculture including fish health, animal welfare, environment, biosecurity and general husbandry[41].

Ireland

Targeted training and guidance has been provided to Border Inspection Post staff of the Department of Agriculture, Food and the Marine (DAFM BIP). Guidance Document SANCO 4788/2009/rev 5 and guidance from the Marine Institute (MI) is available as technical support for BIP staff. A specific guidance document in relation to Article 3 of Regulation (EC) No 1099/2009 was in preparation in 2014 between DAFM, the MI and the Irish Fisheries Board (Bord Iascaigh Mhara – BIM). This document should encompass aspects of fish welfare identified as being important in the OIE Aquatic Code. Adherence will be assessed by a team of eight regionally based Veterinary Inspectors who have a significant on-site presence on fish farms in the course of their duties under Council Directive 2006/88/EC. These Veterinary Inspectors are already experienced in the fundamentals of animal welfare and, according to the CA, are due to receive specialist training on fish welfare.

United Kingdom

Staff performing official controls are appropriately trained for their area of competence, as required in Article 6 of Regulation (EC) No 882/2004. Induction and continuous training of Fish Health (FH) inspectors ensures that all inspectors are properly trained on all aspects of their work, which supports an effective system of Aquatic Animal Health (AAH) official controls. In Scotland, the principal CA is Marine Scotland (MSC). A number of Animal and Plant Health Agency (APHA) staff have been trained in fish welfare (with the focus on farmed salmon because of the importance of the industry in Scotland) and carry out a small number of visits each year in conjunction with Fish Health Inspectors of Marine Scotland (MSC FHIs). They are occasionally called to give advice in welfare cases. In the salmon sector, most production is now done in accordance with RSPCA Freedom Food requirements and there is an industry Code of Practice for Finfish Aquaculture, which – in the absence of specific legislation – provides some assurance of reasonable standards of welfare.

[41] EFTA Surveillance Authority; Doc. 763821; 2015

Italy

The DG Health mission found that there is sufficient access to training for official veterinarians (OVs) who carry out official controls in the area of Aquatic Animal Health (AAH), but there is a lack of understanding of the objectives of AAH legislation and relating official controls. This indicates that not all staff performing official controls are effectively trained for all tasks in their field of work, as required in Article 6 of Regulation (EC) No 882/2004.

Poland

There is a two-year (340 hours) post-graduate course on fish diseases for veterinarians. Seventy veterinarians (officials and private veterinary practitioners) have been declared fish specialists and 24 are following the course. In an audit report in 2015, it was mentioned that comprehensive training programmes for operators, private veterinarians and official staff provide the aquaculture sector in Poland with competent and professional support. Through these training activities highly trained private veterinary fish specialists are available to the aquaculture operators and training on fish health and management is available to operators. Of particular relevance for this study, it was found that the competent authorities have issued national guidelines in cooperation with stakeholders, with the aim of altering traditional consumer and retailer behaviour in a direction that is beneficial for carp welfare.

Greece

In 2015, the Central Competent Authority for Aquaculture Animal Health issued a checklist for on-farm inspections including conditions for animal welfare. However, an audit in 2015 found that in some regions insufficient training and limited expertise among official veterinarians undermined the effectiveness of the surveillance and reduced the benefit for the operators.

Spain

There has been no formal initiative at national level to set up a training system for aquatic animal health specialists working in the public and private sectors. Consequently, fish welfare training is not provided at all by the authorities. However, Autonomous Communities (ACs) have associations of private veterinarians specialising in aquaculture animal health (Asociación de Defensa Sanitaria Ganadera – ADS). In addition to the implementation of health programmes involving surveillance and programmes for the control and prevention of major diseases of relevance to aquaculture, this association also carries out annual training for farmers and workers, which includes the relevant aspects of prevention and control of aquatic diseases. Official staff from the AC veterinary services also participate in this training. However, fish welfare is not explicitly mentioned as a training topic.

For the private sector, the situation regarding welfare training is different. The majority of companies consulted by the study confirm that their staff receive welfare training for relevant activities, including transport and stunning/killing. Training is regularly updated and is executed according to private standards requirements.

Compulsory fish welfare training

In some cases, welfare training is required by law, such as in Norway, where all personnel handling live farmed fish must undergo fish welfare training. All fish welfare training courses are approved by the Norwegian food safety authority. Private training suppliers exist that offer fish welfare training approved by the Norwegian food safety authority, such as Åkerblå[42].

Training in the fish farming industry is driven by two factors: one is that most national standards or codes of practice specify the need for staff training; the second is that training is mandatory for adherence to most private standards.

Fish welfare training is generally less advanced than livestock welfare training. However, it can be concluded that staff in the fish farming industry is increasingly trained, especially when companies

[42] http://akerbla.no/

adopt private standards. It is difficult to determine the extent to which fish welfare training meets OIE standards.

Table 20 presents the study findings on welfare training of Competent Authority staff in the case study EEA States.

Table 20. Replies from Competent Authorities in EEA States on training received by CA staff on farmed fish welfare during transport and slaughter in 2009 and 2013

Country	Training in 2009	Training in 2013	Is training regularly repeated?
NO	Yes	No	Training is repeated irregularly
UK	Unknown	Unknown	Unknown
IE	-	-	-
PL	No	Yes	No
CZ	Yes	Yes	No
DE	-	-	-
DK	No	No	No
FR	-	-	-
IT	No	No	No
GR	No	No	No
ES	Unknown	Unknown	Unknown

Source: Targeted survey of Competent Authorities in EEA States carried out by the study.
** According to the FAWC report[43], Scotland Fish Health Inspectors receive training in farmed fish welfare from the Animal Health Veterinary Laboratory Agency (AHVLA).*
- No replies were received from France and Ireland, nor from DE for this question.

Table 21 presents the study findings on welfare training of aquaculture industry staff in the case study EEA States.

[43] FAWC Report, Opinion on the Welfare of Farmed Fish at the Time of Killing (UK, May, 2014)

Table 21: Replies from industry representatives on training provided to aquaculture industry staff during transport and stunning/killing

EEA State	Species	Companies providing transport				Companies that stun/kill		
		Number of replies	Is personnel trained for transporting fish from loading until unloading? (number of 'yes' replies)	Is training regularly repeated? (number of 'yes' replies & frequency)	Is training about what to do on hot/cold days included? (number of replies)	Number of replies	Is the personnel trained for the work in the abattoir/farm? (number of 'yes' replies)	Are trainings regularly repeated? (number of 'yes' replies & frequency)
NO	Salmon	-			-	-		
UK	Salmon	-			-	-		
IE	Salmon	1	1	1 – yearly	No (1)	1	1	1 – yearly
PL	Trout, carp	6	6	4 – yearly	Yes (6)	2	2	2 – less than one time per year
CZ	Carp	-			-	-		
DE	Carp	2	2	2 – one or two times per year	Yes (2)	2	2	Following IFC standard
DK	Trout	-			-	1	1	1 – yearly
FR	Trout	-			-	-		
IT	Trout, Sea bream/ Sea bass	-			-	1	1	1 – two times per year
GR	Sea bream/ Sea bass	3	3	3 – one or two times per year	Yes (3)	3	3	3 – one or two times per year
ES	Sea bream/ Sea bass	4	4	No	No (4)	2	2	2 – less than one time per year

Source: Targeted survey of the aquaculture industry carried out by the study

- *No replies were received*

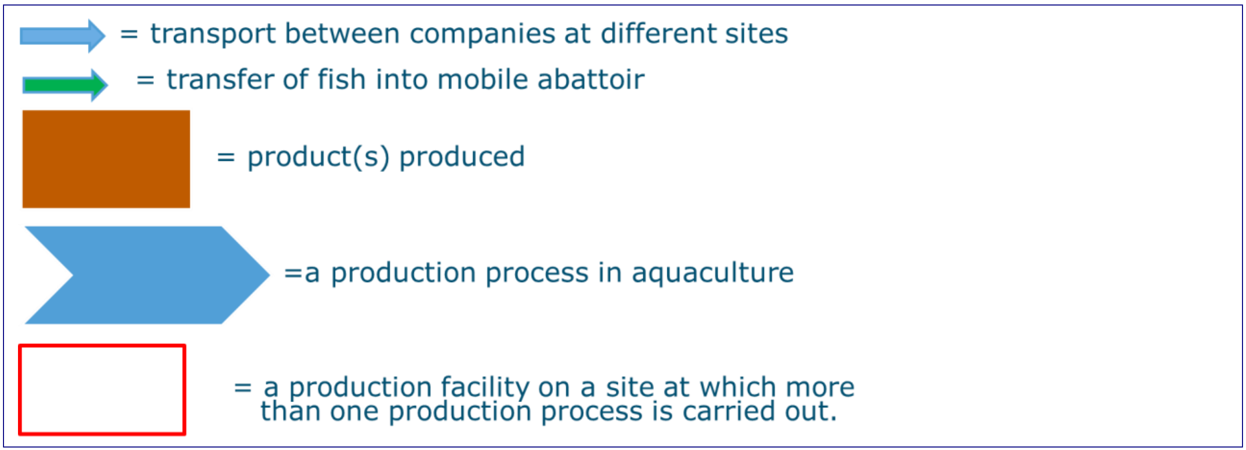
8. Current situation on welfare practices in case study countries

8.1. A brief overview of the aquaculture industry in the EEA States

For each country and fish species an overview of relevant aquaculture production chains is presented. Please note that we prepared figures which contain steps that are relevant for this study. In practice the aquaculture chains are more complex. The relevance of each chain for each country and fish species is indicated.

For all figures we used symbols, as shown in Figure 5. The location where the fish is slaughtered is indicated in the figure (on a truck, at a farm, mobile abattoir or abattoir).

Figure 5. Symbols used in figures of aquaculture production chains

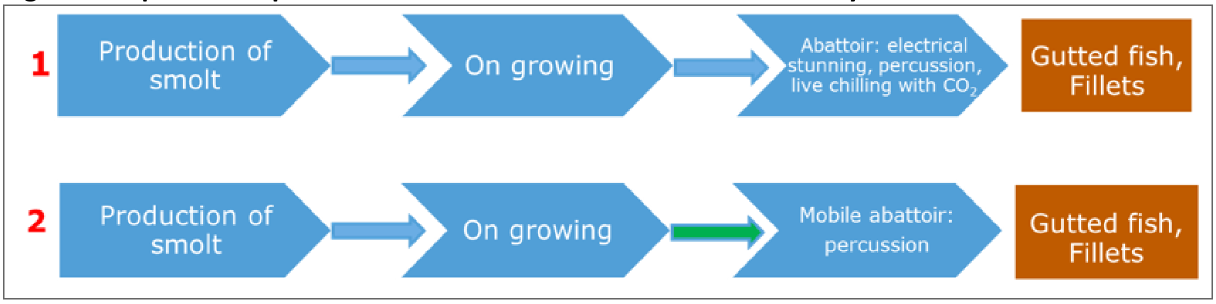


8.1.1. Atlantic salmon

For Atlantic salmon produced in Norway, the United Kingdom and Ireland the aquaculture production chains are presented below.

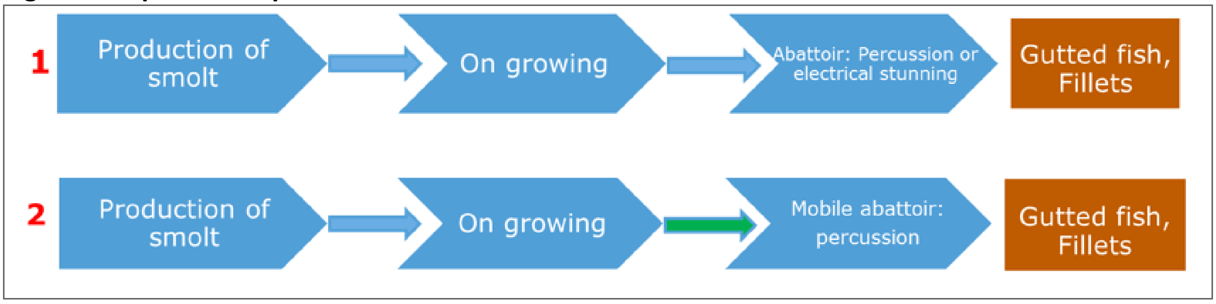
In Figure 6 it is shown that at an abattoir in Norway, one of the following three stunning methods can be applied: electrical stunning, percussion or live chilling combined with moderate CO_2 levels. On board a vessel (mobile abattoir), percussion is used in Norway.

Figure 6. Aquaculture production chains for Atlantic salmon in Norway



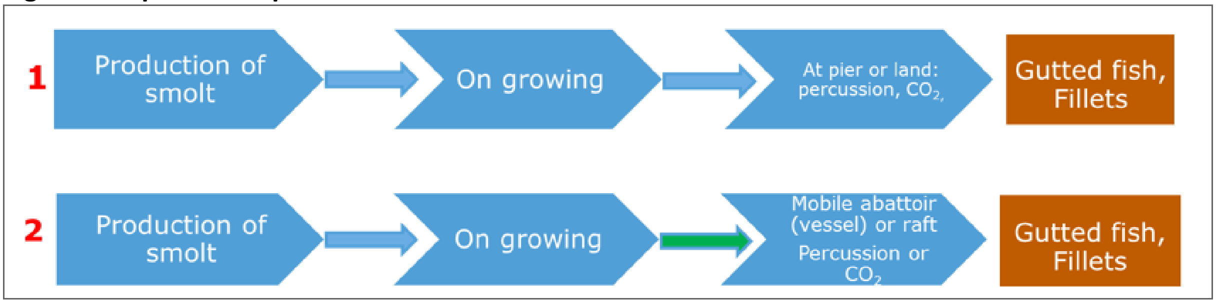
In Norway, the market share for chain 1 is over 95 % and chain 2 is less than 5 %.

Figure 7. Aquaculture production chains for Atlantic salmon in the UK



In the UK, the market share of chain 1 is 80 %, of which percussion is 95 % and electrical stunning 5 %. Chain 2 has a 20 % market share.

Figure 8. Aquaculture production chains for Atlantic salmon in Ireland



The market shares for Ireland are 90 % and 10 % for chains 1 and 2 respectively. In Ireland 7-8 % of all fish are still stunned in a carbon dioxide bath.

8.1.2. Common carp

Relevant aquaculture chains for the production of common carp are show below for Poland, the Czech Republic and Germany. In Poland the market share of chain 1 is 70 % and chain 2 , 15 %. Live sales of carp to consumers is a characteristic for aquaculture in Poland and the Czech Republic.

Figure 9. Aquaculture production chains for common carp in Poland

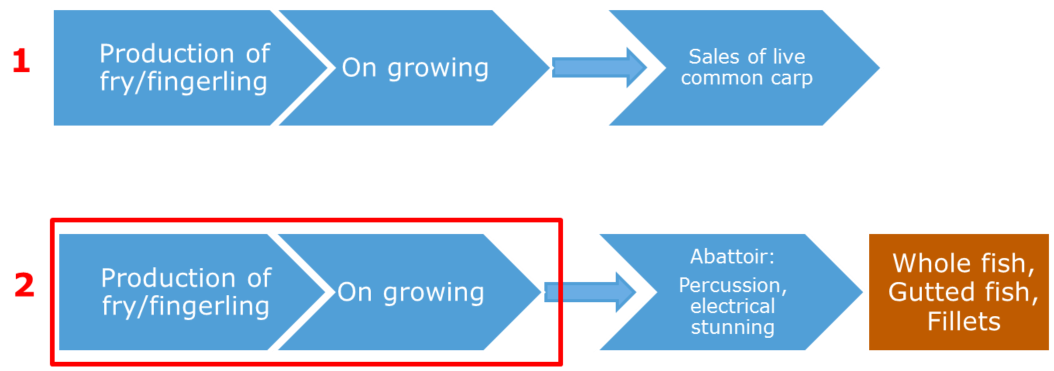


Figure 10. Aquaculture production chains for common carp in the Czech Republic

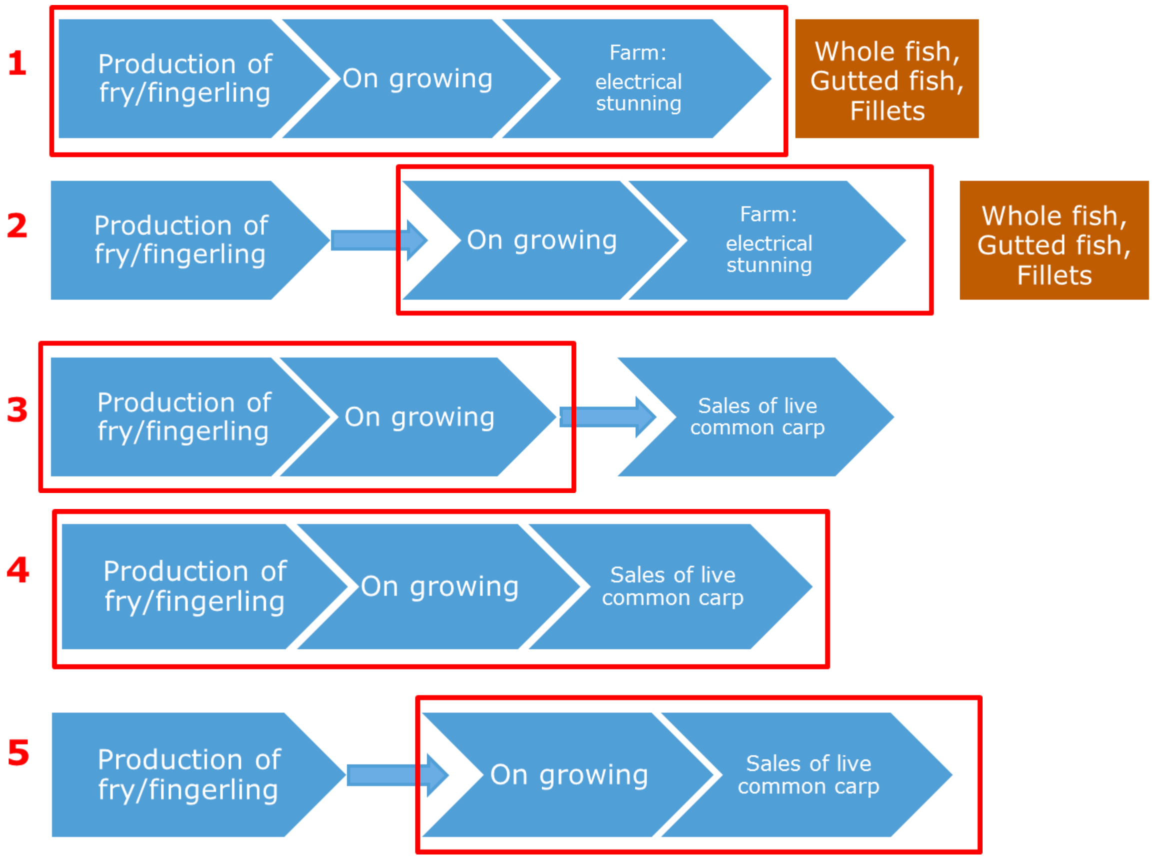
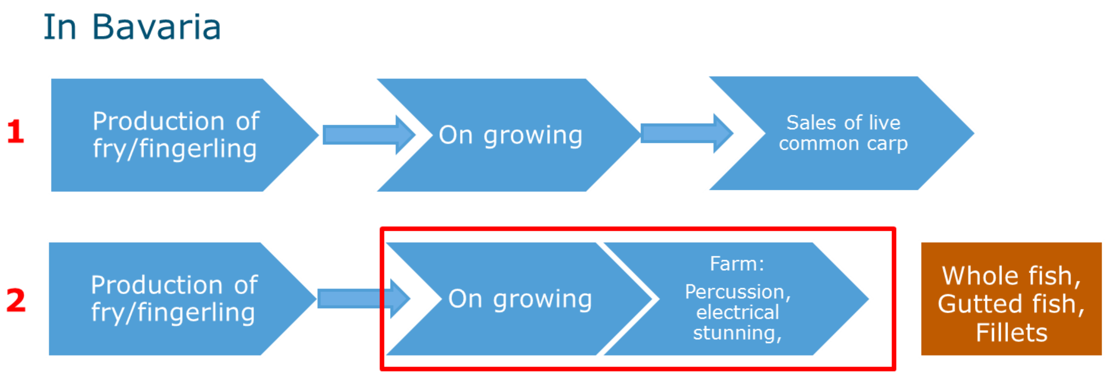
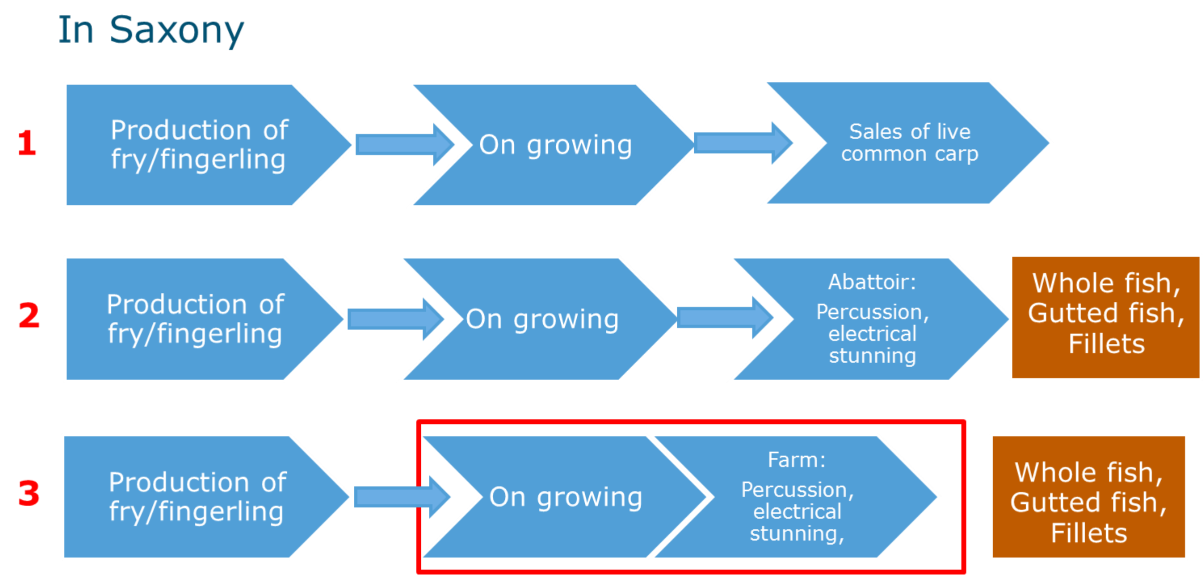


Figure 11. Aquaculture production chains for common carp in Germany



The production chains in Bavaria (see above) differ from those in Saxony (see below). In Bavaria the major chain is number 1, with a market share of 70 %. For Saxony, the major chain is chain 2.

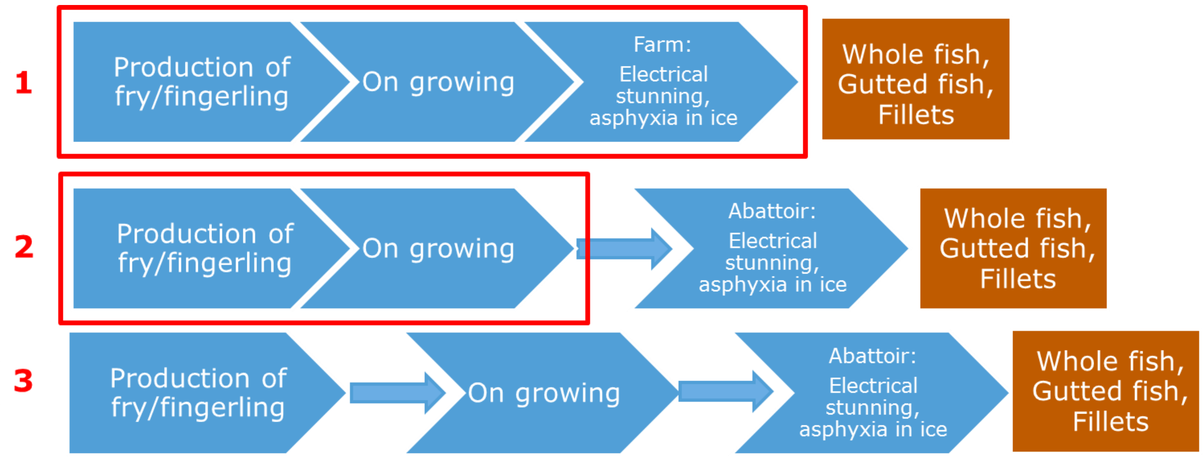
In Germany carp are sold live to restaurants, but not to consumers.



8.1.3. Rainbow trout

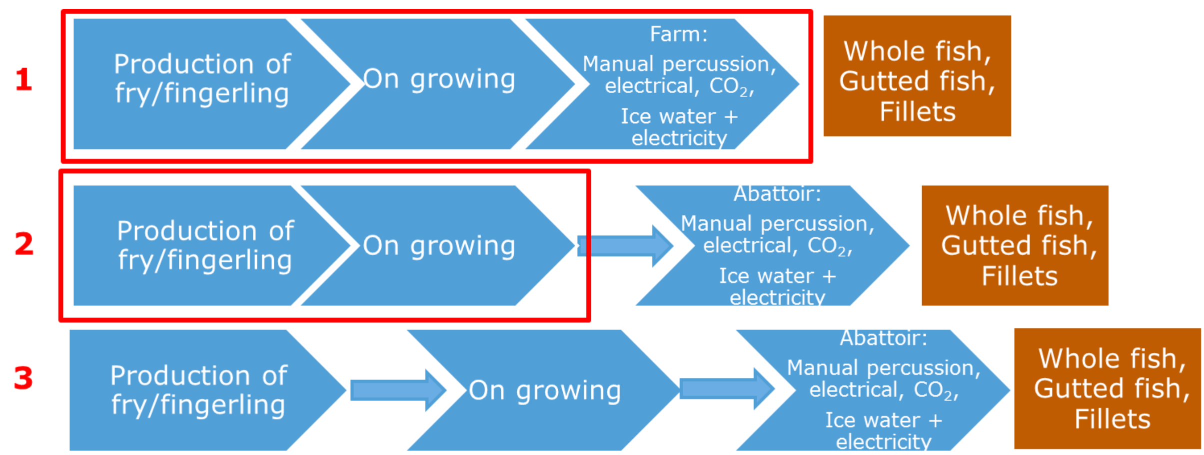
Aquaculture production chains for freshwater rainbow trout in Denmark, France, Italy and Poland are shown below.

Figure 12. Aquaculture production chains for freshwater rainbow trout in Denmark



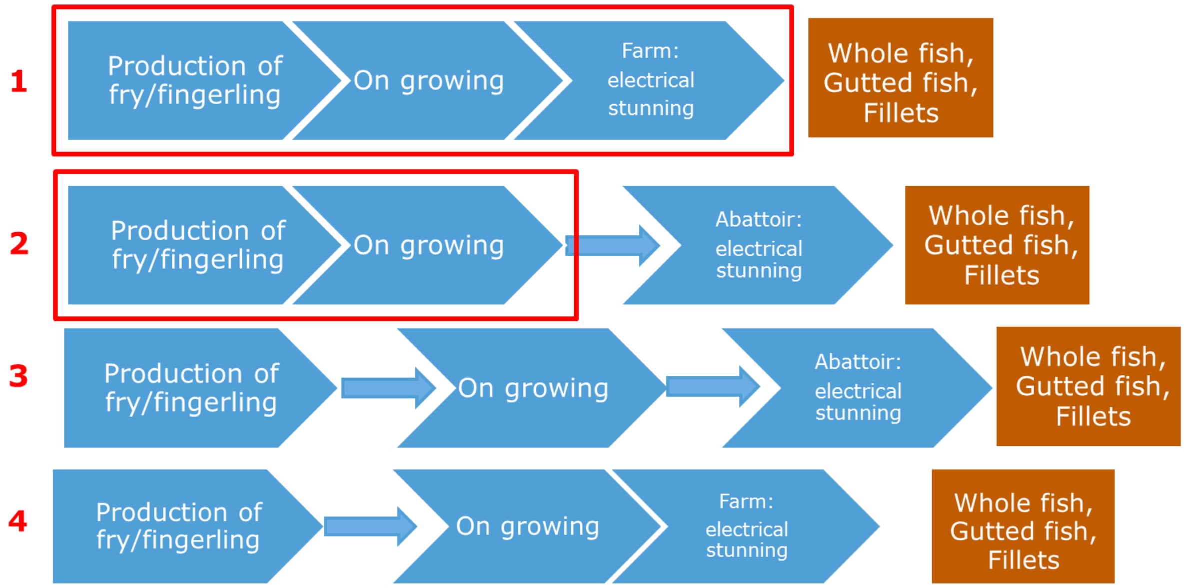
In Denmark the market shares for chains 1, 2 and 3 are 30 %, 50 % and 20 % respectively. In Denmark electrical stunning is applied or the fish are killed by asphyxia in ice without stunning them first.

Figure 13. Aquaculture chains for freshwater rainbow trout in France



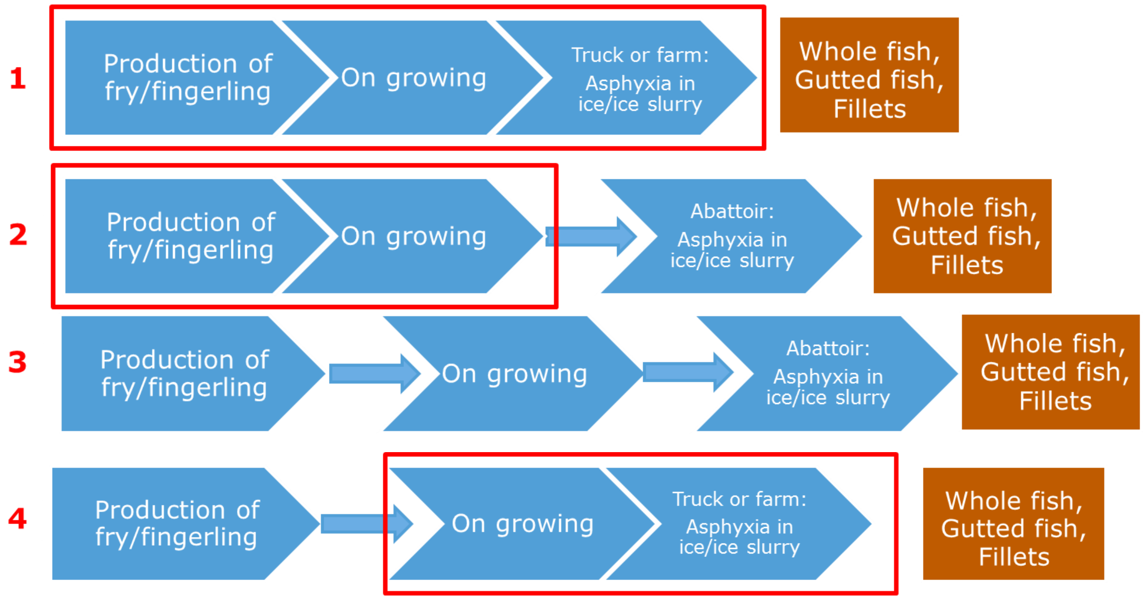
In France four production chains are relevant for slaughter. The most important is chain 2. It should be noted that fish may also be chilled in ice water prior to electrical stunning.

Figure 14. Aquaculture production chains for fresh water rainbow trout in Italy



Four production chains are used in Italy.

Figure 15. Aquaculture production chains for freshwater rainbow trout in Poland



In Poland, chain 2 is the most important.

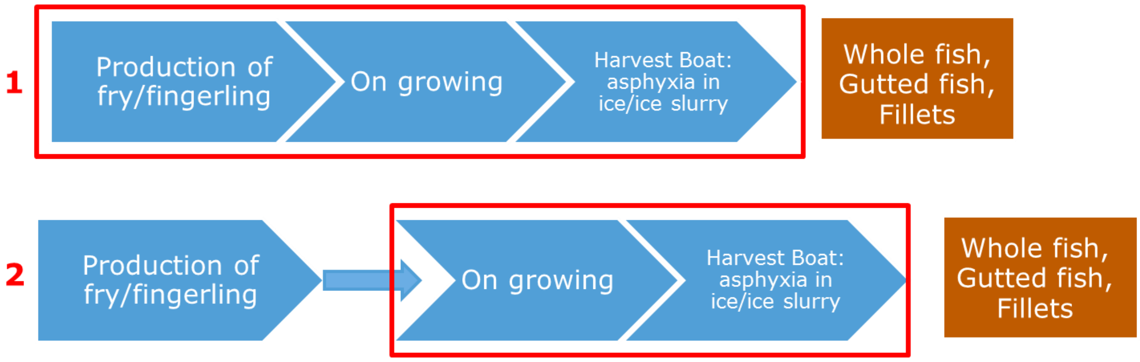
In chain 1, fish are slaughtered on a truck by asphyxia in ice and subsequently transported. This process is very similar to the process used on board a harvest boat for sea bream and sea bass (see Figure 9 and Figure 10).

8.1.4. Gilthead sea bream and European sea bass

The aquaculture production chain for gilthead sea bream and European sea bass is presented below for Greece and Spain. For Italy, two chains are relevant.

Figure 16. Aquaculture production chain for gilthead sea bream and European sea bass in Greece and Spain

Figure 17. Aquaculture production chains for gilthead sea bream and European sea bass in Italy



8.2 Practices during transport

Three types of transport were considered by the study: overland transport by truck, sea transport by well-boat and air transport by helicopter. Transport by helicopter is exceptional (only in the UK with a 1 % market share).

8.2.1 Road transport

For overland transport, tanks are mounted on a truck. These tanks are usually constructed of fibreglass with a sealable hatch and a valve/pipe discharge point. Sensors to measure temperature and oxygen levels in the water are present. Measured values are monitored within the cab of the vehicle. This type of transport is closed system. It is essential that levels of ammonia and carbon dioxide are controlled to avoid that fish species-specific thresholds are exceeded and, therefore, management of loading the truck, density of fish, temperature of the water and duration of the journey and the way the truck is driven are essential parameters.

Road transport is used in UK and Ireland to transfer smolts to a well-boat. In Greece, Spain and Italy trucks are used to transport fry/fingerling and juvenile sea bass and sea bream to a ferry. In both Greece and Spain the truck container is placed on a boat and taken to the cages. Well-boats are only used in Spain to transport fish to the sea cages; a truck is unloaded by gravity into the well-boat. In Denmark, France, Italy and Poland, marketable rainbow trout are transported by truck to a slaughterhouse.

In Germany, Poland and the Czech Republic, marketable fish are transported by truck to a slaughterhouse, or in Poland and the Czech Republic sold live to consumers. In Germany, marketable carp may be sold live to restaurants.

8.2.2 SEA TRANSPORT

With regard to transport by well-boat, an open single pass flow-through system or closed haul system can be used. A flow-through system is not feasible on a truck and therefore transport by truck is only possible with a closed system, which may result in too high levels of CO_2 (King, 2009) and TAN (Total ammonia nitrogen, i.e. the sum of NH_3 and NH_4^+ concentrations) in the water. The choice of an open or a closed system depends upon whether there are bio-security issues associated with the fish itself, local regulations, or risks of contamination with fish pathogens along the transport route (Rosten and Kristensen, 2011).

Studies on transport of Atlantic salmon smolts revealed no negative impact on their welfare when a well-boat with an open system was used (Nomura et al., 2009).

With regard to marketable Atlantic salmon and smolts, studies performed by Erikson et al. (1997) and Iversen et al (2005) revealed that loading the well-boat is stressful for the fish. It should be noted that cortisol levels during transportation of smolts in open system well-boats returned to normal during transportation (Iversen et al., 2005). Only when transportation took place during rough weather, which could be considered a stressor, plasma cortisol levels remained elevated in smolts (Iversen et al., 2005).

A report of the Norwegian Scientific Committee for Food Safety (VKM, 2008) made a number of recommendations regarding closed transportation of marketable salmon and smolts. The concentration of CO_2 should be below 20 mg/l. A lowering of the water temperature during transportation can reduce the impact of several factors on fish physiology and welfare. The temperature reduction must be carried out with great care and should not exceed 1.5 °C/hr. For Atlantic salmon and rainbow trout, the transportation temperature should not be below 6 °C. It is not possible to give an exact limit for the maximum transportation time in a closed system. This will depend on fish species, density, and temperature and water treatment in the transport unit.

Transport by well-boat is performed in Norway, UK and Ireland for smolts and marketable Atlantic salmon.

Transport by well-boat is also used in Greece, Spain and Italy to transfer fry or juvenile sea bass and sea bream to cages for on-growing.

8.2.3 AIR TRANSPORT

Data on air transport of smolts, which is a closed system , is very scarce. This type of transport is only mentioned once in the report of the Norwegian Scientific Committee for Food Safety. Transportation of smolts by helicopter is an exception (less than 1 % market share in the UK) for economic reasons.

8.3 PRACTICES AT SLAUGHTER

8.3.1 ATLANTIC SALMON

Norway

For Atlantic salmon, current slaughter methods are percussive stunning and electrical stunning. Live chilling in combination with low to moderate carbon dioxide levels is used to a limited extent.

Stunning by live chilling with carbon dioxide

A recent development is combined live chilling with moderate carbon dioxide levels (65-257 mg/l) and oxygen levels of 70-100 % saturation (Erikson et al., 2006). It should be noted that live chilling or a combination of live chilling and carbon dioxide will not stun fish immediately. An evaluation of live chilling with carbon dioxide showed that the use of carbon dioxide in combination with live chilling was found to be stressful (Erikson, 2011). The market share is less than 5 % and will decrease to zero, as this method is phased out.

Electrical stunning

For electrical stunning after removing out of water, which is used for Atlantic salmon (EFSA, 2009a), the fish is placed in a device, for example, a conveyer belt as negative electrode with steel flaps suspended. Electroencephalogram (EEG) recordings showed that Atlantic salmon can be stunned immediately (Lambooij et al, 2010). The market share of this method is approximately 50 % in Norway.

For electrical stunning after dewatering, it is essential that the fish is not exposed to pre-shocks and the fish enters the stunner head-first. To prevent the need to orient the fish (i.e. when it does not matter whether the fish enters head-first or tail-first) the stunner needs to be modified to ensure that the current is passed through the brain and not side-to-side through the tail (Daskalova et al, 2016). This result was obtained in a laboratory setting and should also be evaluated in a commercial setting.

At present 25-30 % of salmon are oriented prior to electrical stunning after dewatering in Norway. As stunners are being replaced by ones with a device to orient the fish, the percentage will increase.

The current method for killing stunned salmon is gill cutting. However, a study by Lambooij *et al.* (2010) revealed that a third of salmon may recover after the application of a gill cut. This implies that an effective method for killing of salmon stunned by electricity needs to be developed. Registration of EEGs revealed that decapitation of a stunned Atlantic salmon is an adequate method to prevent recovery (Roth, Gerritzen, Bracke, Reimert and Van de Vis, *in preparation*) an alternative for killing after electrical stunning is percussion (Lambooij et al., 2010).

With regard to product quality, a waveform for an electrical current, which results in a very low incidence of injuries in Atlantic salmon, consists of a combination of a direct and alternating electrical current for stunning after dewatering (Roth et al., 2009). These injuries are not a welfare issue, as immediate loss of consciousness can be induced by applying electricity. Longer exposure times (more than 10 seconds) to electricity will lead to an early onset of rigor mortis in Atlantic salmon, due to electrical stimulation. For pre-rigor filleting of Atlantic salmon it is important to keep the electrical stimulation at a minimum.

Percussion

At present the market share for percussive stunning of salmon is approximately 50 %. Percussive stunning is the application of a blow to the head manually or by using a device. For Atlantic salmon the method is applied by a stunner. Prior to its application the fish are removed from the water. At commercial slaughterhouses or a mobile abattoir for salmon an automatic device is commonly used. A recent development is a so-called swim-in percussive stunner[44] for which the salmon do not have to be dewatered prior to entering the stunner. The current market share of swim-in stunners is less than 5 % in Norway. Data showing the impact of the short stay of the Atlantic in a confined environment prior to administering the blow to the head in the stunner are not available yet.

It should be noted that a blow to head is painful when the stun is not achieved immediately. Percussive stunning should, therefore, result in an immediate stun (with 1 second). Its efficacy is related to applied force and adjustment to size of the fish (Roth et al., 2007). EEG recordings showed that at an air pressure higher than 8.1 bar to drive the bolt, consciousness and sensibility are lost immediately in Atlantic salmon without recovery, under conditions used (i.e. the equipment for percussion that was provided by SeaSide). For a percussive stunner manufactured by another company, the threshold value for the pressure may be different. However, at air pressure above 8.1 bar, carcass damage occurred, which is not a welfare issue (an immediate stun is achieved) but an

[44] www.baader.com

economic one. At this air pressure EEG recordings revealed that consciousness is lost immediately without recovery (Lambooij et al., 2010). It is noteworthy that the threshold of 8.1 bar was established for the percussive stunner of a particular company. For percussive stunners of other companies this threshold may be different. However, at an air pressure higher than 8.1 bar, damage to the head occurred (Lambooij et al., 2010). This carcass damage can be an economic issue when the fish is sold head-on.

United Kingdom

Most Atlantic salmon in the United Kingdom are stunned and killed by percussion, as this the only method that is allowed by RSPCA Assured. Subsequently, a gill cut is applied. Some slaughterhouses may use electrical stunning. In an amendment of the RSPCA Assured standards, which will become available in the course of 2017, it is stated that electrical stunning is also permitted.

Ireland

Marketable Atlantic salmon are stunned by percussion. Carbon dioxide is still used for stunning, however its market share (at present 7-8 %) is decreasing.

8.3.2 COMMON CARP

Poland, Czech Republic and Germany

A manually applied blow to the head (Poland and Germany)
In Poland exposure of carp to air at ambient temperature for 1-10 minutes is performed to exhaust the carp and facilitate the manual application of the blow on the head. Air exposure for 1-10 minutes is stressful for carp as the animal is lying on its side in a dry tank, possibly covered by conspecifics that are also attempting to escape. A blow to the head without prior exposure to air is also applied (EFSA, 2009c). In Germany, percussion is applied instantaneously.

Electrical stunning (Czech Republic and Germany)
Equipment for electrical stunning of carp in water is also used. Subsequently, the fish is gutted (EFSA, 2009c). Literature which provides more information is scarce. It is not known whether equipment used for electrical stunning is effective, as the equipment is not purchased from one of the major manufacturers. In the Czech Republic, a killing method is not applied after electrical stunning, whereas in Germany a gill-cut or a blow to the head is used as the killing method. It is possible that carp in the Czech Republic recover from electrical stunning.

In an experimental setting, manual percussion of common carp, as applied in Poland, was compared to an experimental method for electrical stunning. The results revealed no major differences in product quality (Van de Vis et al., 2006)

8.3.3 RAINBOW TROUT

Denmark and Italy

Electrical stunning
In Denmark, electrical stunning of rainbow trout is carried out in water. Stunning is followed by a throat cut.

Denmark and Poland

Asphyxia
An experiment performed on rainbow trout in the UK showed that it took 9.6 minutes before visually evoked responses (VERs) on the EEG were lost during live chilling in ice (Robb and Kestin, 2002). In the view of EFSA (2009d), exposure to ice or ice water is a welfare hazard for conscious trout. Live chilling is followed by evisceration (portion sized trout) or exsanguination and evisceration (large trout) (EFSA, 2009d).

France

Exposure to ice water prior to electrical stunning

Exposure of rainbow trout to a temperature shock prior to electrical stunning initiates a stress response (as reviewed in Robb and Kestin, 2002), which can be avoided by applying electrical stunning without exposure to a temperature drop.

Carbon dioxide stunning

Transfer of rainbow trout to water that is saturated with carbon dioxide is very stressful, as vigorous attempts to escape from the tank are observed (Robb and Kestin, 2002).

Manual percussion

A correctly applied blow to head induces immediate loss of consciousness without recovery (Robb and Kestin, 2002).

8.3.4 EUROPEAN SEA BASS AND GILTHEAD SEA BREAM

Greece, Spain and Italy

Asphyxia in a slurry of ice and seawater
All sea bass and sea bream are killed by immersion a slurry of ice and seawater (EFSA, 2009b). In most cases, violent attempts to escape are made and maximal stress responses are initiated (Robb & Kestin, 2002). In the view of EFSA live chilling prior to stunning should not be used for these species (EFSA, 2009b).

Greece

Electrical stunning

Electrical stunning of these species is still an exception (Lines and Spence, 2014). In Greece electrical stunning is still experimental. The method involves exposing the fish to an electrical field created using two plate electrodes in a water tank or ring or plate electrodes in a pipe through which water is pumped. The stunned sea bass can be killed after electrical stunning by immersion in a slurry of ice and water without recovery (EFSA, 2009b). Electrical stunning of sea bass in sea water followed by chilling in ice water in a laboratory setting results in an immediate stun without recovery, as shown on the EEG (Lambooij et al, 2008). Recently, trials with electrical stunning have been performed to put this into practice for sea bass and sea bream in Greece. Analysis of product quality of electrically stunned sea bass showed that it is similar to that of sea bass killed in ice water without prior stunning (Knowles et al. 2007).

With regard to safety for workers, practical experience in Norway with this technology in a “wet environment” shows that adequate safety measures are able to protect staff who operate the stunner.

9. Current situation on welfare practices in non-EEA countries

9.1. Chile

Atlantic salmon

Farming. Atlantic salmon is the major species cultured in Chile with an annual production of 660 000 tonnes in 2016 in approximately 1 300 licensed salmon farms, concentrated in Regions 10 (Los Lagos) and 11 (Aysén). This represents 95 % of the production.

Smolts are produced in land-based hatchery facilities (flow-through and increasingly also in recirculation). On-growing to marketable size is performed sea water cages.

Transport. Smolts are transferred to the sea cages by truck and well-boat. When the fish reach harvestable size in Chile, they are transported live by well-boat to land-based processing plants where they are slaughtered. During transport the water is oxygenated or aerated and oxygen levels and temperature are monitored. In total, there are 35 processing plants distributed throughout the regions 10 and 11.

Slaughter. Fish are mainly slaughtered at the slaughter house/processing plant. The stunning/killing method used is percussion.

9.2. Canada

Atlantic salmon

Farming. Atlantic salmon is the major salmonid farmed in Canada, although Chinook and Coho species are also farmed. During 2011-2015 on average 122 300 tonnes of salmon were produced annually. Salmon is produced predominantly in British Columbia, New Brunswick, Newfoundland and Nova Scotia. Salmon represents an average of 70 % of total Canadian aquaculture volume.

Smolts are produced in land-based hatchery facilities (flow-through and recirculation). On-growing to marketable size is performed in sea water net pens and some land-based systems.

Transport. Smolts are transferred to a truck with freshwater using a vacuum pump. During transport the water is oxygenated or aerated and oxygen levels in the tanks and temperature are monitored. The fish are drained by gravity into the hold of a well-boat.

On arrival at the farm for on-growing, the smolt are transferred into the cages by pumping.

Slaughter. Fish are mainly slaughtered at the farm by percussion (using a SI 5 percussive stunner) or the fish are transported by well-boat to a land-based slaughterhouse. Subsequently, bleeding-out is performed in an ice slurry on board a ship. In Newfoundland, the cages with salmon are towed to the land-based processing plant and the fish are pumped out and stunning by percussion.

Freshwater rainbow trout

Approximately 7 000 tonnes of marketable freshwater trout is produced annually. Fry/fingerlings are transferred by truck from tanks to cages in lakes. The truck is loaded by using a pump. Unloading is done by gravity or pumping.

At the farm the trout are stunned by electrical stunning and are subsequently killed by transferring them into a tank with an ice slurry. Large trout are stunned by percussion.

9.3. CHINA

Common carp

Farming. Common carp is a widespread freshwater fish. It is the oldest reared species and currently the number one in aquaculture. The estimated annual production of common carp in China is around 2.5 million tonnes and exceeds the weight of all other fish, such as trout and salmon, produced by aquaculture worldwide.

Common carp is cultured in diverse systems; mainly in extensive and semi-extensive pond systems, in polyculture and in combination culture, such as with rice. In China, common carp is produced for local consumption, aiming at getting the fish as fresh (alive) as possible to the consumer.

Transport. Fingerlings may be produced at specialised hatcheries and are transferred to the grow-out pond. The fish are caught by netting and mainly transported in plastic bags with oxygen (or in different types of transport vehicles).

Marketable fish are mainly sold live (at restaurants and in the supermarket), where they are kept for a few days in aquaria, or as whole fish (alive or dead) at the market.

Slaughter. After harvest at the pond site, the carp are killed by asphyxia. In restaurants, fresh fish may be killed by a manual blow to the head followed by evisceration or decapitation. Asphyxia is still one of the commonly used methods in commercial practice. Carp in China is not processed in commercial processing plants. Slaughter of carp does not adhere to OIE standards.

Electrical stunning is used in Europe and can be an effective method for stunning carp. However, it is effective only if correctly applied. Improvement of the electrical devices and the electrical current to be applied are needed (Dashkalova et al., 2016).

9.4. TURKEY

European sea bass / gilthead sea bream

Farming. Sea bass and sea bream culture in Turkey is similar to the situation in Greece. The production capacity in Turkey increased in recent years and the annual production is now similar or even higher than in Greece. As it concerns the same fish species and Turkey and Greece are exporting their products to the same markets, the procedures are highly comparable.

For both Turkey and Greece, the majority (up to 70 %) of the production takes place in fully integrated fish farms. In 20 % of cases, specialised hatcheries are used and farming and processing belong to the same company. In less than 5 % of the production, the hatchery and farm belong to one company and the processing plant is owned by another company, while only 5 % of production takes place in three different companies (hatchery, grow-out and processing plant).

Transport. In Turkey there are general regulations regarding fingerling transport. Fingerlings are transferred by netting into a truck and transported to well-boats. Trucks come with two persons; continuous oxygen and temperature monitoring is carried out. Detailed recording takes place with a focus on quality rather than on welfare. Afterwards, well-boat transportation is used to transfer to the cages at sea. Unloading takes place by net or carrying the transportation tank to the cage by boat and unloading by pipe with gravity.

Transportation of live marketable fish does not take place as 100 % of the fish are killed near the cages.

Slaughter. As in Greece, the vast majority of sea bass and sea bream are killed by immersion in ice slurry at the sea-cage site. Asphyxia in ice of both sea bass and sea bream does not adhere to OIE standards.

Electrical stunning is still an exception. However, customers include UK supermarkets such as Tesco, and they are asking for electrical stunning of fish prior to killing. Nowadays, offshore electrical stunning is applied by 5-6 companies in Turkey, while two companies use electrical stunning on a commercial scale in Greece. In that case, fish are transferred by pumping. After stunning, the fish are killed in ice slurry.

Offshore electrical stunning demands stricter procedures than land-based slaughter with regards to the surrounding water and the offshore conditions, which may include strong winds. In both countries, 99-100 % of the farms are GlobalGAP certified.

Compared to 2013, current handling and killing procedures are similar, but the fish are handled more carefully during netting (with smaller amounts of fish). In 2017, electrical stunners for sea bass and sea bream were put into operation on board harvest boats in Turkey.

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10. Analysis of welfare practices

This chapter analyses current practices in European aquaculture regarding the welfare of farmed fish during transport and at time of killing. Current practices are described per species and per country; national legislation and codes of practice are identified; private standards are identified together with their share of the market, and; information is provided on the availability of equipment and methods for good welfare, as well as knowledge in their use.

10.1. Introduction

This introduction describes the phases relevant for the study of rearing of Atlantic salmon (*Salmo salar*), common carp (*Cyprinus carpio*), rainbow trout (*Oncorhynchus mykiss*) in fresh water systems, European sea bass (*Dicentrarchus labrax*) and gilthead sea bream (*Sparus auratus*).

10.1.1. Production of fry, juveniles and smolts

After first feeding in a fresh water system, the fry of **Atlantic salmon** are termed parr. Parr are kept in tanks in a variety of systems in Norway, Ireland and the United Kingdom. The parr-smolt transformation – smoltification – consists of a range of morphological, physiological and behavioural changes that pre-adapt the smolts to a life in sea water. On transfer to sea water following smoltification, smolts are transported to cages with varying sizes for on-growing in the countries selected in this study (EFSA, 2008a).

For transport of fry and juveniles or smolts of Atlantic salmon to a farm for on-growing, the following steps can be distinguished:

1. Fasting to prepare fish for transport
2. Crowding
3. Loading the vehicle
4. Transport
5. Unloading the vehicle

Transfer of fry/juveniles or smolts at a farm to a holding system is performed to start the process of on-growing.

Hatcheries of **sea bass and gilthead sea bream** grow the fish up to a size of 10-20 g or even more (50-60 g) to adhere to the requirements of offshore farms to stock larger fish. Stocking fish of 50-60 g reduces the need for initial grading, which is a step during rearing. Countries like Greece, Spain and Italy use cages for on-growing of both fish species (EFSA, 2008b).

Some **rainbow trout** producers in Europe are vertically integrated, i.e. they carry out all stages of the production cycle. Most farms are specialised in different life-cycle stages such as egg production, fry and fingerling production, or on-growing (EFSA, 2008c). This implies that fingerlings are transferred from one farm to another by means of transport. Note, however, that the study focused on the assessment of transport of marketable freshwater rainbow trout.

For **common carp**, various life stages during rearing can be distinguished, such as embryos, yolk sac fry, free swimming fry, nursed fry, fingerling, overwintering carp, on-growers, marketable fish (EFSA, 2008d). Transport of carp fry/fingerlings was not included in the study and transport of marketable carp was assessed for Germany, Poland and the Czech Republic.

10.1.2. ON-GROWING

On-growing is the last phase of rearing to produce food fish. Several types of aquaculture are used for on-growing of food fish: ponds, land-based intensive flow-through systems, cage farming and recirculation aquaculture systems (EFSA, 2008a, 2008b, 2008c, 2008d). In Europe, the production of Atlantic salmon, European sea bass and gilthead sea bream relies mainly on cage culture at sea. For rainbow trout in fresh water, the on-growing stage is done in different systems across Europe (e.g. circular tanks with a flow-through system, earth ponds and raceways with recirculation). For common carp, the major production system is pond culture. A fish pond is the oldest system used in aquaculture.

In general, the steps in the chain of transport and slaughtering of marketable fish can be distinguished as described below. It is known that marketable Atlantic salmon, common carp and freshwater rainbow trout are transported prior to slaughter, whereas European sea bass and gilthead sea bream are slaughtered only at the premises of the farm where on-growing took place.

The steps are:

1. Fasting to prepare fish for slaughter;
2. Crowding;
3. Transport from the rearing enclosure to a slaughterhouse or handling at the farm prior to commencing slaughter at the premises of farm;
4. Lairage after receipt of the marketable fish;
5. Restraint (fixation of an animal for a proper application of a stunning method). If no stunning is applied, step 7 follows step 4;
6. Stunning means rendering the animal unconscious and insensible so as to reduce avoidable stress and discomfort prior to killing. The application of a method like percussion can be suitable to achieve both stunning and killing; in this case step 7 is not performed;
7. Killing.

Equipment used for handling fish, stunning and killing, or killing without stunning does not depend on the rearing system used for on-growing.

Relevant audit and fact-finding mission reports from EFSA and DG Health and Food Safety, Health and Food Audits and Analysis (formerly Food and Veterinary Office – FVO) have been referenced to provide content for this chapter.

10.2. WELFARE DURING TRANSPORT

10.2.1. BACKGROUND

Transport involves feed withdrawal, physical handling (crowding and netting, or pumping) and keeping fish in a modified environment during transport due to potential differences in temperature, water quality, light intensity, water flow, density of fish, noises and vibrations, compared to rearing during on-growing. A modified environment is inevitable when fish are being transported. The main aim in managing transport should be to provide a safe environment and minimise unnecessary stress or discomfort to the fish before, during and after transport.

As the process of transport may imply an accumulation of stressors, loading the fish into the transport tanks of a truck or well-boat and unloading should be made as stress-free as possible. Stress caused by loading, unloading or both may cause the fish to shed mucus and increase its metabolic rate, thereby compromising water quality. In addition, a badly managed process of crowding, loading or unloading fish may lead to injuries in the animals and/or an increase in aggression among fish; or even mortality.

Ideally the fish should be pumped to avoid dry netting of large batches of fish. It is essential to ensure that sufficient staff is on hand to make loading and unloading a smooth and quick operation, thereby minimising delays and the total time that the fish are in the tanks of a truck or well-boat.

Regarding density of fish during transport, the deterioration of water quality is the overriding factor, so the journey length; the size, life stage and species of fish; and whether the system used is open or closed will determine densities. In a closed system, carbon dioxide (King, 2009) and ammonia – which are both excreted by fish – will increase during transport. Oxygen needs to be administered to avoid hypoxia.

10.2.2. WELFARE ASPECTS

There is no clear-cut definition of animal welfare. Animal welfare (including fish welfare) is defined in different ways (Duncan and Fraser, 1997; Spruijt et al., 2001; Korte et al., 2007; Broom, 2011; Hagen et al., 2011; Ohl and van der Staay, 2012). Key to all definitions is that poor welfare is associated with overtaxing the coping capacity, i.e. allostatic overload, of animals (McEwen and Wingfield, 2003).

It should be noted that a stress response in fish or any other animal is in principle a regular physiological and behavioural response, as it essential for an animal to cope with a challenge. However, when this response is mal-adaptive in a sentient animal, its welfare is impaired; its coping capacity is overtaxed. Successive or cumulative exposure to stressors, which may occur during transport, may compromise the allostatic capacity of an animal and lead to allostatic overload and poor welfare (Korte et al., 2007; Ohl and van der Staay, 2012). Allostatic overload may lead to pathologies and mortality (Koolhaas et al., 2011). This overload can be measured in fish species in relation to stressors, such as parameters related to stress-axis and immune-system functioning (Wendelaar Bonga, 1997; Huntingford et al., 2006; Martins et al., 2012). In addition, transport may lead to severe injuries and mortality; both are clear indicators of a transport process that is beyond control.

10.2.3. RECIRCULATION AQUACULTURE SYSTEMS (RAS)

A recirculation aquaculture system (RAS) may be used as a closed system for transport of one or more of the selected species in this study.

In the aquaculture sector, fish are often cultured in flow-through aquaculture systems like cages suspended in the sea or rivers, or in ponds, or in raceways. However, the lack of available space for growth, limited fresh water availability, and concerns about pollution prohibit expansion of these systems (Badiola et al., 2012). Land-based recirculation aquaculture systems (RAS) are seen as a good solution and opportunity to further increase the yield of the aquaculture sector and answer future demands for fish protein. They are considered to be advanced technology-biology interaction systems that require continuous monitoring (Lekang, 2007).

RAS are mainly used in the Netherlands and Denmark (Martins et al., 2009). However, their use in countries such as Norway and Canada is increasing. The system is basically a very large aquarium tank that is connected to several physical and biological filters to remove nitrogenous compounds, solid waste and carbon dioxide from the water. During physical treatment, solid waste is removed by mechanical filtration. The nitrogenous compounds are removed by bio-filtration. During biological filtration, bacteria convert ammonia into nitrate, which is less harmful. In the next step a denitrification filter can be used to remove nitrate from the water. Subsequently, most of the water is re-used. RAS were initially developed to facilitate intensive fish farming in areas where fresh water was limited. By re-using water, these systems can recycle 90 - 99 % of the water used (Badiola et al., 2012).

It should be noted that a biological system, which is part of RAS, to convert ammonia into nitrate depends on the presence of microbial flora in a biofilter. Prior to the use of the biofilter, it needs to be started up as bacteria are absent in a filter that has not been used before or has been thoroughly cleaned. To start a biofilter takes 2-9 weeks (Ter Veld, personal communication). Another issue is the need to clean and disinfect a transport vehicle thoroughly after use for reasons of bio-security. Cleaning and disinfection will stop the biofilter from functioning, as the microbial flora is killed and has to be replaced. Given these facts, it is unlikely that the use of RAS in a closed system for transport of the selected fish species is practicable.

10.2.4. ROAD TRANSPORT

In this study two types of transport are considered: overland transport by truck and sea transport by well-boat. For overland transport, tanks are mounted on a truck. These tanks are usually constructed of fibreglass with a sealable hatch and a valve/pipe discharge point. Sensors to measure temperature and oxygen levels in the water are present. Measured values are monitored within the cab of the vehicle. This type of transport is a closed system. It is essential that levels of ammonia and carbon dioxide are controlled to avoid species-specific thresholds being exceeded. Management of loading of the truck, density of fish, temperature of the water, duration of the journey and the way the truck is driven are therefore essential parameters for road transport.

Trucks or containers can be transported by ferry to sea cages. Nevertheless the fish are still in a the tank on a truck or a container that was transported by a truck to the ferry.

Road transport is used in UK and Ireland to transfer smolts to a well-boat. In Greece, Spain and Italy, trucks are used to transport fry and juvenile sea bass and sea bream to a ferry. The ferry takes the fish to the sea cages. Only in Spain are well-boats used for transport of both fish species. The study assessed road transport of marketable freshwater rainbow trout in Denmark, Italy, France and Poland to a slaughterhouse.

For carp in Germany, Poland and the Czech Republic, no transfer of fry or fingerlings for on-growing is reported between companies and this transport was therefore not included in our study. In these countries, we assessed transport of marketable carp.

Current transport practice of fry/fingerlings, smolts and marketable fish were assessed, using the OIE standards (Table 6) as bench mark. An overview of this assessment of road transport for the selected species in this study is presented for smolts in Table 22 (truck) and Table 23 (well-boat); for sea bass and sea bream fry/fingerlings or juveniles in Table 24 (transport by truck) and Table 25 (transport by well-boat); for marketable Atlantic salmon in Table 26, for marketable rainbow trout Table 27 and for marketable common carp in Table 28.

Table 22. Overview of transport methods used for Atlantic salmon smolts: transfer by truck to well-boat

Transport practice	Norway (Protocol used at companies) Market share > 95%	United Kingdom RSPCA Assured (90%)	Ireland Salmon Handbook (100%)
Is there a contingency plan for all phases of transportation? How are sick, injured or moribund fish during transport treated?	No, trucks are not used, as this process is too slow to load a well-boat in Norway.	Yes Fish removed and humanely culled	Yes Killed humanely.
Information provided by the farm to hauler Are the fish fit for travel? Major injuries, diseases are absent. Fish are not moribund; how are these aspects assessed?		Yes, visually (silvering, swimming pattern and shape) Visually	Yes Certificate
Information provided by the farm to the hauler What is the length of feed deprivation at the farm; how many degree days? Is the feed deprivation sufficient to clear the gut? Are there other methods used to prepare the fish for transport?		Yes No longer than 48 h during summer and winter Yes No	Yes 24-48 h. Probably yes No
Is the transport planned by the hauler? Is there a protocol available? Is a vehicle designed for this purpose? Is the vehicle maintained and cleaned prior to transport? What it the age of the vehicle? Are the post-transport activities described (receipt of smolt at farm for on-growing or marketable fish at abattoir)? Specify.		Yes Yes Yes Yes Not known Yes	Yes Yes Yes Yes Not known Yes
Crowding in holding tank or cage? Crowding practices inclusive of total duration of crowding. Monitoring of oxygen levels during crowding?	In tank. Lowering water level/s	In tank. Lowering water level. Depends on volume tank. Is this done?	In tank. Lowering water level Depends on volume tank. Is this done? Yes

Transport practice	Norway (Protocol used at companies) Market share > 95%	United Kingdom RSPCA Assured (90%)	Ireland Salmon Handbook (100%)
Skill of personnel		Yes Trained	Trained
Which type of equipment is used to take fish out of the holding tank/cage, e.g. fully automated? e.g. brailing or pumping? Specify pump height and speed. Is it fully automated? Specify the routines for maintaining good water quality for duration of transfer. Are the fish out of water? Length of time out of water? Are fish injured due to faulty constructions/fittings? Skill of personnel. Operation of equipment, is it according to manufacturer's recommendation?		Automated. Matsusaka pump used. Pump height is a minor issue. Fish stay in water. Damage is avoided. Staff trained. Yes	Pump or brailing is used. Pump height is a minor issue. Fish stay in water. Damage is avoided. Staff trained. Yes
<u>Loading the transport vehicle.</u> Which type of equipment is used? Is it fully automated? e.g. brailing or pumping? Specify pump height and speed. Specify the routines for maintaining good water quality for duration of loading. Handling out of water? Length of time out of water. Skill of personnel. Operation of equipment, is it according to manufacturer's recommendation?		Automated. Matsusaka pump used. Pump height is a minor issue. Fish stay in water. Only briefly out of water to pass counter Damage is avoided. Staff trained. Yes	Pump or brailing is used. Pump height is a minor issue. Fish stay in water. Only briefly out of water to pass counter Damage is avoided. Staff trained. Yes
<u>Specify the duration of transport in relation to means of transport used.</u>		≤ 8 h	Not known

Transport practice	Norway (Protocol used at companies) Market share > 95%	United Kingdom RSPCA Assured (90%)	Ireland Salmon Handbook (100%)
Is sedation or anaesthesia applied during transport? Specify the routines for maintaining good water quality for duration of transport. Which water quality parameters are monitored during transport? Are stops made to change transport water? Are the fish observed during transport; how? Skill of personnel. Operation of vehicle for transport, is it according to manufacturer's recommendation?		No Monitoring T, pH and O_2. Oxygenation. No No Trained. Yes	No Monitoring T, pH and O_2. Oxygenation. No No Trained. Yes
<u>Specify the percentage of transports that operate with closed systems.</u> Specify available equipment for water quality maintenance in closed systems Specify Monitoring of water quality parameters in closed systems.		Truck: closed Oxygenation, removal of CO_2 pH, T, O_2	Truck: closed Oxygenation, removal of CO_2 pH, T, O_2
<u>Unloading the transport vehicle.</u> Which type of equipment is used? Is it fully automated? e.g. brailing or pumping? Specify pump height and speed. Specify the routines for maintaining good water quality for duration of unloading. Handling out of water? Length of time out of water. Skill of personnel. Operation of equipment, is it according to manufacturer's recommendation?		Gravity to transfer to well-boat Not applicable Not applicable As described previously for transportation In water Trained staff. Yes	Gravity to transfer to well-boat Not applicable Not applicable As described previously for transportation In water Trained staff. Yes

Table 23. Overview of transport methods used for Atlantic salmon smolts: transfer by well-boat to sea cages

Means of transport	Transport practice	Norway Protocols used at companies) Market share > 95%	United Kingdom RSPCA Assured (90%)	Ireland Salmon Handbook (100%)
Well-boat Norway: Helicopter not used UK: helicopter 1% or less Ireland: No helicopter	Is there a contingency plan for all phases of transportation? How are sick, injured or moribund fish during transport treated?	Yes Remove fish, if possible.	Yes Fish removed and humanely culled	Yes Killed humanely.
	Information provided by the farm to hauler Are the fish fit for travel? Major injuries, diseases are absent. Fish are not moribund; how are these aspects assessed?	Yes, seawater challenge test. Certificate needed. Visually.	Yes (visually): silvering, swimming pattern and shape Visually	Yes Certificate
	Information provided by the farm to the hauler What is the length of feed deprivation at the farm; how many degree days? Is the feed deprivation sufficient to clear the gut? Are there other methods used to prepare the fish for transport?	Yes 3 days Yes No	Yes Not longer than 48 h. Yes No	Yes 24-48 h. Probably yes. No
	Is the transport planned by the hauler? Is there a protocol available? Is a vehicle designed for this purpose? Is the vehicle maintained and cleaned prior to transport? What it the age of the vehicle? Are the post-transport activities described (receipt of smolt at farm for on-growing or marketable fish at abattoir)? Specify.	Yes Yes Yes Yes Well-boat on average 8 years Yes, specified in protocol	Yes Yes Yes Yes Well- boat on average 8 years Yes, specified in RSCPA-assured standards	Yes Yes Yes Yes Not known Yes, daily log is used.

Means of transport	Transport practice	Norway Protocols used at companies) Market share > 95%	United Kingdom RSPCA Assured (90%)	Ireland Salmon Handbook (100%)
	<u>Crowding in holding tank or cage?</u> Crowding practices inclusive of total duration of crowding. Monitoring of oxygen levels during crowding? Skill of personnel	In tank. Lowering water level Hardly any crowding Yes, normal procedure at farm? Trained	In tank. Lowering water level Duration usually less than 1 h. 2 h maximum. Yes, normal procedure for truck and well-boat transport. Trained	In tank. Lowering water level. 2 h maximum. Yes, normal procedure for truck and well-boat transport. Trained
	Which type of equipment is used to take fish out of the holding tank/tank on a truck, e.g. fully automated? e.g. brailing or pumping? Specify pump height and speed. Is it fully automated? Specify the routines for maintaining good water quality for duration of transfer. Are the fish out of water? Length of time out of water? Are fish injured due to faulty constructions/fittings? Skill of personnel. Operation of equipment, is it according to manufacturer's recommendation?	Gravity Not applicable Fish stay in water. Control of water quality by using procedures at farm and transport by well-boat. Only briefly out of water to pass counter. Damage is avoided. Staff trained. Yes	Gravity. Not applicable Fish stay in water. Control of water quality by using procedures for transport by truck and well-boat. Only briefly out of water to pass counter. Damage is avoided. Staff trained. Yes	Gravity Not applicable. Fish stay in water. Control of water quality by using procedures for transport by truck and well-boat. Only briefly out of water to pass counter. Damage is avoided. Staff trained. Yes
	<u>Loading the transport vehicle.</u> Which type of equipment is used? Is it fully automated? e.g. brailing or pumping?	Automated. Pump used to load well-boat.	Gravity used to load well-boat.	Gravity used to load well-boat.

Means of transport	Transport practice	Norway Protocols used at companies) Market share > 95%	United Kingdom RSPCA Assured (90%)	Ireland Salmon Handbook (100%)
	Specify pump height and speed. Specify the routines for maintaining good water quality for duration of loading. Handling out of water? Length of time out of water. Skill of personnel. Operation of equipment, is it according to manufacturer's recommendation?	Pump height is a minor issue. Fish stay in water. Damage is avoided. Staff trained	Not applicable Fish stay in water. Damage is avoided. Staff trained	Not applicable Fish stay in water. Damage is avoided. Staff trained
	<u>Specify the duration of transport in relation to means of transport used.</u> Is sedation or aesthesia applied during transport? Specify the routines for maintaining good water quality for duration of transport. Which water quality parameters are monitored during transport? Are stops made to change transport water? Are the fish observed during transport; how? Skill of personnel. Operation of vehicle for transport, is it according to manufacturer's recommendation?	24-28 h No Monitoring T, pH and O_2 Oxygenation, CO2 stripping, skimmers used. No Not applicable Trained Yes	>24 h No Monitoring T, pH and O_2 Oxygenation, CO2 stripping, skimmers used. No Not applicable Trained yes	3-30 h No Monitoring T, pH and O_2 Oxygenation, CO2 stripping, skimmers used. No Not applicable Trained yes
	<u>Specify the percentage of transports that operate with closed systems.</u> Specify available equipment for water quality maintenance in closed systems Specify Monitoring of water quality parameters in closed systems.	Well-boat: 100% closed in certain regions Oxygenation, CO_2 stripping, skimmers used. Well-boat: pH, T, O_2	Well-boat: 100% closed in certain regions Oxygenation, CO_2 stripping, skimmers used Well-boat: pH, T, O_2	Well-boat: 100% closed in certain regions Oxygenation, CO_2 stripping, skimmers used Well-boat: pH, T, O_2
	<u>Unloading the transport vehicle.</u> Which type of equipment is used? Is it fully automated? e.g. brailing or pumping?	Vacuum pressure pump (10%) or pressurize	Vacuum pressure pump or pressurized	Vacuum pressure pump or pressurized

Means of transport	Transport practice	Norway Protocols used at companies) Market share > 95%	United Kingdom RSPCA Assured (90%)	Ireland Salmon Handbook (100%)
	Specify pump height and speed. Specify the routines for maintaining good water quality for duration of unloading. Handling out of water? Length of time out of water. Skill of personnel. Operation of equipment, is it according to manufacturer's recommendation?	hull (90%). Minor issue Not applicable Not applicable In water Not applicable Trained staff. Yes	hull. Minor issue Not applicable Not applicable In water Not applicable Trained staff. Yes	hull. Minor issue Not applicable Not applicable In water Not applicable Trained staff Yes

Table 24. Overview of transport methods used for fry/fingerling/juvenile of gilthead sea bream and sea bass: transfer by truck to well-boat or by truck on a ferry to cages for on-growing

Means of transport	Transport practice	Greece Market share 100% GMP at companies	Spain Market share 100% GMP at companies	Italy (90% market share API Code of Practice)
Truck. In Spain containers on truck can also be placed on a workboat	Is there a contingency plan for all phases of transportation? How are sick, injured or moribund fish during transport treated?	Yes. Fish removed and killed, if possible	Yes Fish removed and killed, if possible	Yes Fish removed and killed, if possible
	<u>Information provided by the farm to hauler</u> Are the fish fit for travel? Major injuries, diseases are absent. Fish are not moribund; how are these aspects assessed?	Yes. No injuries, disease or moribund. Visually Certificate	Yes. No injuries, disease or moribund. Visually Certificate	Yes. No injuries, disease or moribund. Visually Certificate
	<u>Information provided by the farm to the hauler</u> What is the length of feed deprivation at the farm; how many degree days? Is the feed deprivation sufficient to clear the gut?	Yes 40 degree days Yes No	Yes ≥24 h Yes No	Yes 50 degree days Yes No

Means of transport	Transport practice	Greece Market share 100% GMP at companies	Spain Market share 100% GMP at companies	Italy (90% market share API Code of Practice)
	Are there other methods used to prepare the fish for transport?			
	Is the transport planned by the hauler? Is there a protocol available? Is a vehicle designed for this purpose? Is the vehicle maintained and cleaned prior to transport? What it the age of the vehicle? Are the post-transport activities described (receipt of fry/fingerling at farm for on-growing or marketable fish at abattoir)? Specify.	Yes Yes Yes Yes Not known Yes. Protocols at farm	Yes Yes Yes Yes Not known Yes. Protocol	Yes Yes Yes Yes Not known Yes. Protocol
	Crowding in holding tank or cage? Crowding practices inclusive of total duration of crowding. Monitoring of oxygen levels during crowding? Skill of personnel	In tank. Move fish to one side of the tank by a screen Yes	In tank. Lowering water level/screens. Yes	In tank. Lowering water level/screens. Yes
	Which type of equipment is used to take fish out of the holding tank/cage, e.g. fully automated? e.g. brailing or pumping? Specify pump height and speed. Is it fully automated? Specify the routines for maintaining good water quality for duration of transfer. Are the fish out of water? Length of time out of water? Are fish injured due to faulty constructions/fittings? Skill of personnel. Operation of equipment, is it according to manufacturer's recommendation?	Pump or 15 l buckets Minor issue Partly automated. No No Trained Yes	Netting and fish in buckets < 10 s out of water Damage is avoided. Staff trained. Yes	Pump or net is used. Pump height is a minor issue. Pump: fish stay in water. Net: < 10 s out of water Damage is avoided. Staff trained. Yes
	Loading the transport vehicle. Which type of equipment is used? Is it fully automated? e.g. brailing or pumping? Specify pump height and speed.	Pump or 15 l buckets Pump height is a minor	Netting and fish in buckets	Pump or net is used. Pump height is a minor

Means of transport	Transport practice	Greece Market share 100% GMP at companies	Spain Market share 100% GMP at companies	Italy (90% market share API Code of Practice)
	Specify the routines for maintaining good water quality for duration of loading. Handling out of water? Length of time out of water. Skill of personnel. Operation of equipment, is it according to manufacturer's recommendation?	issue Oxygenation. Gradual change of water temperature to avoid exposure of fish to rapid change. No Trained. Yes	Oxygenation aeration Not more than 10 s Trained. Yes	issue. Oxygenation. CO_2 stripping during long transport < 10 s out of water Trained. Yes
	<u>Specify the duration of transport in relation to means of transport used.</u> Is sedation or anaesthesia applied during transport? Specify the routines for maintaining good water quality for duration of transport. Which water quality parameters are monitored during transport? Are stops made to change transport water? Are the fish observed during transport; how? Skill of personnel. Operation of vehicle for transport, is it according to manufacturer's recommendation?	1 h-8 h No Oxygenation T and O_2 No, for long transport water is chilled to 14 C. Visually Trained Yes	12 h maximum No Monitoring T, O_2. Oxygenation. No. During summer transport at night Visually Trained. Yes	Maximum 36 h (transport from France or Spain) No Monitoring T, pH and O_2. Oxygenation. Yes, to control T water. Visually Trained Yes
	<u>Specify the percentage of transports that operate with closed systems.</u> Specify available equipment for water quality maintenance in closed systems	Container: closed Oxygenation	Truck or container: closed Oxygenation,	Truck: closed Oxygenation, stripper to remove CO_2

Means of transport	**Transport practice**	**Greece Market share 100% GMP at companies**	**Spain Market share 100% GMP at companies**	**Italy (90% market share API Code of Practice)**
	Specify Monitoring of water quality parameters in closed systems.	T and O_2	T, O_2	pH, T, O_2
	Unloading the transport vehicle. Which type of equipment is used? Is it fully automated? e.g. brailing or pumping? Specify pump height and speed. Specify the routines for maintaining good water quality for duration of unloading. Handling out of water? Length of time out of water. Skill of personnel. Operation of equipment, is it according to manufacturer's recommendation?	Containers are taken from trucks and placed on workboat that sails to cages for on growing. Unloading by gravity into sea cages. No pumps used Oxygenation of transport tanks Not applicable Trained. Yes	Nets or gravity to transfer into well-boat. Or containers are taken from trucks and placed on workboat that sails to cages for on growing No pumps used Oxygenation of transport tanks. Intake of fresh seawater every 2h on ferry Not applicable Trained. Yes	Containers are taken from trucks and placed on workboat that sails to cages for on growing. Unloading by gravity into sea cages. No pumps Oxygenation, intake water to control temperature Not applicable Trained. Yes

Table 25. Overview of transport methods used for fry/fingerling/juvenile of gilthead sea bream and sea bass: transfer by well-boat to sea cages

Transport practice	Greece Market share 100% GMP at companies	Spain Market share 100% GMP at companies	Italy
Is there a contingency plan for all phases of transportation? How are sick, injured or moribund fish during transport treated?	No well-boats used	Yes Fish removed and killed, if possible	*No well-boat used*
<u>Information provided by the farm to hauler</u> Are the fish fit for travel? Major injuries, diseases are absent. Fish are not moribund; how are these aspects assessed?		Yes. No injuries, disease or moribund. Visually Certificate	
<u>Information provided by the farm to the hauler</u> What is the length of feed deprivation at the farm; how many degree days? Is the feed deprivation sufficient to clear the gut? Are there other methods used to prepare the fish for transport?		Yes $\geq$24 h Yes No	
<u>Is the transport planned by the hauler</u>? Is there a protocol available? Is a vehicle designed for this purpose? Is the vehicle maintained and cleaned prior to transport? What it the age of the vehicle? Are the post-transport activities described (receipt of fry/smolt at farm for on-growing or marketable fish at abattoir)?		Yes Yes Yes Yes Not known Yes	
<u>Crowding in holding tank or cage?</u> Crowding practices inclusive of total duration of crowding. Monitoring of oxygen levels during crowding? Skill of personnel		Already done for transport by truck	
Which type of equipment is used to take fish out of the holding tank/cage, e.g. fully automated? e.g. brailing or pumping? Specify pump height and speed. Is it fully automated? Specify the routines for maintaining good water quality for duration of transfer. Are the fish out of water? Length of time out of water?		Already done for transport by truck	

Transport practice	Greece Market share 100% GMP at companies	Spain Market share 100% GMP at companies	Italy
Are fish injured due to faulty constructions/fittings? Skill of personnel. Operation of equipment, is it according to manufacturer's recommendation?			
Loading the transport vehicle. Which type of equipment is used? Is it fully automated? e.g. brailing or pumping? Specify pump height and speed. Specify the routines for maintaining good water quality for duration of loading. Handling out of water? Length of time out of water. Skill of personnel. Operation of equipment, is it according to manufacturer's recommendation?		Container from truck is placed on ferry.	
Specify the duration of transport in relation to means of transport used. Is sedation or anaesthesia applied during transport? Specify the routines for maintaining good water quality for duration of transport. Which water quality parameters are monitored during transport? Are stops made to change transport water? Are the fish observed during transport; how? Skill of personnel. Operation of vehicle for transport, is it according to manufacturer's recommendation?		36 hours maximum to Canary Islands No Monitoring T, pH and O_2. Oxygenation, CO2 stripping, skimmers used. No Not applicable Trained. Yes	
Specify the percentage of transports that operate with closed systems. Specify available equipment for water quality maintenance in closed systems Specify Monitoring of water quality parameters in closed systems.		Well-boat: 100% closed in certain regions Oxygenation, CO2 stripping, skimmers used pH, T, O_2	
Unloading the transport vehicle. Which type of equipment is used? Is it fully automated? e.g. brailing or pumping?		Vacuum pressure pump	

Transport practice	Greece Market share 100% GMP at companies	Spain Market share 100% GMP at companies	Italy
Specify pump height and speed. Specify the routines for maintaining good water quality for duration of unloading. Handling out of water? Length of time out of water. Skill of personnel. Operation of equipment, is it according to manufacturer's recommendation?		Minor issue Not applicable Not applicable In water Trained staff. Yes	

Table 26. Overview of transport methods used for marketable Atlantic salmon

Means of transport	Transport practice	Norway Protocol used at companies) Market share > 95%	United Kingdom RSPCA Assured 90%	Ireland Salmon Handbook (100%)
Well-boat	Is there a contingency plan for all phases of transportation? How are sick, injured or moribund fish during transport treated?	Yes If possible culled	Yes Not specified	Yes Not specified
	<u>Information provided by the farm to hauler</u> Are the fish fit for travel? Major injuries, diseases are absent. Fish are not moribund; how are these aspects assessed?	Yes Yes Visual	Yes Yes Visual	Yes, only registered transporters Yes Visual
	<u>Information provided by the farm to the hauler</u> What is the length of feed deprivation; how many degree days? Is the feed deprivation sufficient to clear the gut? Are there other methods used to prepare the fish for transport?	Yes 9-14 days in summer and 10-21 days in winter Yes No	Yes 48 h (according to RSPCA-assured 72 h maximum) Yes, but may be not in winter. No	Yes Not more than 14 days Yes No
	Is the transport planned by the hauler? Is there a protocol available?	Yes Yes	Yes Yes	Yes Yes

Means of transport	Transport practice	Norway Protocol used at companies) Market share > 95%	United Kingdom RSPCA Assured 90%	Ireland Salmon Handbook (100%)
	Is a vehicle designed for this purpose? Is the vehicle maintained and cleaned prior to transport? What it the age of the vehicle? Are the post-transport activities described (receipt of fry/smolt at farm for on-growing or for lairage of marketable fish at abattoir)? Specify.	Yes Yes On average 8 years Yes, described in protocol.	Yes Yes Could be on average 8 years No, no waiting cages are used at abattoir	Yes Yes Not known. No, no waiting cages are used at abattoir.
	Crowding in holding tank or cage? Crowding practices inclusive of total duration of crowding. Monitoring of oxygen levels during crowding? Skill of personnel	Cage, duration 1-2 h h sometimes Trained	Cage 2- h maximum Yes and T as well. Trained	Cage2h maximum If fish show signs of stress, oxygen provided. O_2 should be monitored at T > 12 °C. Trained
	Which type of equipment is used to take fish out of the holding tank/cage, e.g. fully automated? e.g. brailing or pumping? Specify pump height and speed. Is it fully automated? Specify the routines for maintaining good water quality for duration of transfer. Are the fish out of water? Length of time out of water? Are fish injured due to faulty constructions/fittings? Skill of personnel. Operation of equipment, is it according to manufacturer's recommendation?	Vacuum pump Height is minor issue Yes No May happen Trained Yes	Vacuum pump Height is minor issue Yes No May happen Trained Yes	Vacuum pump Height is minor issue Yes No May happen Trained Yes
	Loading the transport vehicle. Which type of equipment is used? Is it fully automated? e.g. brailing or pumping? Specify pump height and speed.	Pump Vacuum pump 3-5 m. Pump	Pump Vacuum pump Pump height	Pump Vacuum pump Pump height

Means of transport	Transport practice	Norway Protocol used at companies) Market share > 95%	United Kingdom RSPCA Assured 90%	Ireland Salmon Handbook (100%)
	Specify the routines for maintaining good water quality for duration of loading. Handling out of water? Length of time out of water. Skill of personnel. Operation of equipment, is it according to manufacturer's recommendation?	height minor issue. Monitoring of oxygen, pH and T No Trained Yes	minor issue Monitoring of oxygen, pH and T No Trained Yes	miner issue. Monitoring of oxygen, pH and T No Trained Yes
	Specify the duration of transport in relation to means of transport used. Is sedation or anaesthesia applied during transport? Specify the routines for maintaining good water quality for duration of transport. Which water quality parameters are monitored during transport? Are stops made to change transport water? Are the fish observed during transport; how? Skill of personnel. Operation of vehicle for transport, is it according to manufacturer's recommendation?	24-28 h No Oxygenation, CO_2 stripping, protein skimmer, when system is closed pH, O2 and T No Camera Trained Yes	24-28 h No Water must be chilled (rate 1.5 C/h). Not lower than 4-6 C. Oxygenation, CO2 stripping, protein skimmer, when system is closed. pH, O2 and T No Camera Trained Yes	3-30 h No Oxygenation, CO2 stripping, protein skimmer, when system is closed. pH, O2 and T No Probably camera Trained Yes
	Specify the percentage of transports that operate with closed systems. Specify available equipment for water quality maintenance in closed systems Specify Monitoring of water quality parameters in closed systems.	Closed in certain regions Oxygenation, CO_2 stripping protein skimmer pH, O_2 and temperature	Closed Oxygenation, CO_2 stripping protein skimmer pH, O_2 and temperature	Closed or open For closed system: CO_2 stripping protein skimmer pH, O_2 and

Means of transport	Transport practice	Norway Protocol used at companies) Market share > 95%	United Kingdom RSPCA Assured 90%	Ireland Salmon Handbook (100%)
				temperature
	Unloading the transport vehicle. Which type of equipment is used? Is it fully automated? e.g. brailing or pumping? Specify pump height and speed. Specify the routines for maintaining good water quality for duration of unloading. Handling out of water? Length of time out of water. Skill of personnel. Operation of equipment, is it according to manufacturer's recommendation?	Vacuum pump movable bulkhead In case of closed system Oxygenation, CO_2 stripping protein No Trained Yes	Vacuum pump movable bulkhead In case of closed system Oxygenation, CO_2 stripping protein No Trained Yes	Vacuum pump In case of closed system Oxygenation, CO_2 stripping No Trained Yes

Table 27.Overview of transport methods used for marketable rainbow trout

Means of transport	Transport practice	Denmark (Market share 100% National legislation and protocols)	France (National legislation market share and and protocols 100%)	Italy (Market share legislation and CoP Scottish Finfish 100%)	Poland (Market share < 50%) CoD and GMP)
Road: truck	Is there a contingency plan for all phases of transportation? How are sick, injured or moribund fish during transport treated?	Yes Appropriate treatment	Yes Not known	Yes Not known	Yes Not known
	<u>Information provided by the farm to hauler</u>	Yes yes Yes.	Yes Yes Visual	Yes Yes Visual	Yes Yes Visual

Means of transport	Transport practice	Denmark (Market share 100% National legislation and protocols)	France (National legislation market share and and protocols 100%)	Italy (Market share legislation and CoP Scottish Finfish 100%)	Poland (Market share < 50%) CoD and GMP)
	Are the fish fit for travel? Major injuries, diseases are absent. Fish are not moribund; how are these aspects assessed?	Certificate Visual			
	<u>Information provided by the farm to the hauler</u> What is the length of feed deprivation; how many degree days? Is the feed deprivation sufficient to clear the gut? Are there other methods used to prepare the fish for transport?	Yes 3-5 days summer and 7 days winter Yes No	Yes 2 (summer)-6 days (winter) Yes No	Yes 3-5 days Yes No	Yes 5 days at 2 °C water temperature; 3-4 days at 15-17 °C Yes No
	Is the transport planned by the hauler? Is there a protocol available? Is a vehicle designed for this purpose? Is the vehicle maintained and cleaned prior to transport? What it the age of the vehicle? Are the post-	Yes Yes Yes Yes Not known Waiting period of 1-3 days at abattoir	Yes Yes Yes Yes Not known Waiting period < 7 days at abattoir	Yes Yes Yes Yes Not known Waiting period not specified	Yes Yes Yes Yes 2-7 years Not known

Means of transport	Transport practice	Denmark (Market share 100% National legislation and protocols)	France (National legislation market share and and protocols 100%)	Italy (Market share legislation and CoP Scottish Finfish 100%)	Poland (Market share < 50%) CoD and GMP)
	transport activities described (receipt of farm for on-growing or marketable fish at abattoir)? Specify.				
	Crowding in holding tank? Crowding practices inclusive of total duration of crowding. Monitoring of oxygen levels during crowding? Skill of personnel	Crowding in concrete tank by lowering water level. Fish is pumped into a truck that takes fish to delivery tank at gate farm. From this tank fish are pumped in truck for transport. Yes Trained	Screens used to crowd fish. Yes Trained	Probably screens to crowd fish. Yes Trained	Net used to crowd fish Crowding for < 1h. Yes Trained
	Which type of equipment is used to take fish out of the holding tank/cage, e.g. fully automated? e.g. brailing or pumping? Specify pump height and speed. Is it fully automated?	Pump Yes Minor issue Automated Oxygenation No	Pump (screw) ornet Automated Minor issue Automated ormanually in case of netting In case of a net 5-10 s	Pump crane to lift bucket with water and fish Automated for pump. Minor issue Automated/manually Oxygenation No. Yes, for 30 s for escavator	Hand net/pump Not applicable/ minor issue Manually/automated Oxygenation No/Yes, 10-15 s. May happen

Means of transport	Transport practice	Denmark (Market share 100% National legislation and protocols)	France (National legislation market share and and protocols 100%)	Italy (Market share legislation and CoP Scottish Finfish 100%)	Poland (Market share < 50%) CoD and GMP)
	Specify the routines for maintaining good water quality for duration of transfer. Are the fish out of water? Length of time out of water? Are fish injured due to faulty constructions/fittings? Skill of personnel. Operation of equipment, is it according to manufacturer's recommendation?	May happen Trained Yes	May happen Trained Yes	May happen Trained Yes	Trained Yes
	Loading the transport vehicle. Which type of equipment is used? Is it fully automated? e.g. brailing or pumping? Specify pump height and speed. Specify the routines for maintaining good water quality for duration of loading. Handling out of water? Length of time out of water.	Done at gate farm. Pump Minor issue Oxygenation 0.5 h No Trained Yes	Aqualife pump Automated/manually for net. Height minor issue Oxygenation 0.5- 1h No Trained staff Yes	Vacuum pump/ crane to lift bucket with water and fish. Automated for pump Height minor issue Oxygenation Estimated 0.5-1 h No. Yes, for escavator 30 s Trained staff Yes	Hand net/ pump Manually/Automated Height minor issue. Oxygenation 0.5 h Yes, 10-15 s/No Trained Yes

Means of transport	Transport practice	Denmark (Market share 100% National legislation and protocols)	France (National legislation market share and and protocols 100%)	Italy (Market share legislation and CoP Scottish Finfish 100%)	Poland (Market share < 50%) CoD and GMP)
	Skill of personnel. Operation of equipment, is it according to manufacturer's recommendation?				
	Specify the duration of transport in relation to means of transport used. Is sedation or anaesthesia applied during transport? Specify the routines for maintaining good water quality for duration of transport. Which water quality parameters are monitored during transport? Are stops made to change transport water? Are the fish observed during transport; how? Skill of personnel. Operation of vehicle for transport, is it according to manufacturer's recommendation?	2 h No Oxygenation Insulated tanks T and O_2 No Not possible Trained Yes	2-6 h No Oxygenation. Insulated tanks T and O_2 No Not possible Trained Yes	Not specified No Oxygenation. Insulated tanks T and O_2 No Not possible Trained Yes	0.5- 12h No Oxygenation. Not all trucks have insulated tanks. T and O_2 No Not possible Trained Yes
	Specify the	100%	100%	100%	100%

Means of transport	Transport practice	Denmark (Market share 100% National legislation and protocols)	France (National legislation market share and and protocols 100%)	Italy (Market share legislation and CoP Scottish Finfish 100%)	Poland (Market share < 50%) CoD and GMP)
	percentage of transports that operate with closed systems. Specify available equipment for water quality maintenance in closed systems Specify Monitoring of water quality parameters in closed systems.	Oxygenation T and O_2	Oxygenation T and O_2	Oxygenation T and O_2	Oxygenation T and O_2 and sometimes pH
	Unloading the transport vehicle. Which type of equipment is used? Is it fully automated? e.g. brailing or pumping? Specify pump height and speed. Specify the routines for maintaining good water quality for duration of unloading. Handling out of water? Length of time out of water. Skill of personnel. Operation of equipment, is it according to manufacturer's recommendation?	Gravity No - Oxygenation No Trained. Yes	Gravity No - Oxygenation No Trained Staff. Yes	Gravity No - Oxygenation No Trained Staff. Yes	Gravity No - Oxygenation No Trained. Yes

Table 28. Overview of transport methods used for marketable common carp

Means of transport	Life stage of the selected fish species	Transport practice	Poland (mostly during winter) CoD Market share 100%	Czech Republic (mostly during winter) National legislation and Code of practices market share 100%	Germany National legislation and protocols market share 100%
Road: by truck	Marketable fish	Is there a contingency plan for all phases of transportation? How are sick, injured or moribund fish during transport treated?	Not on paper, rely on staff Not known	Yes Dead fish taken out.	No Appropriate treatment
		<u>Information provided by the farm to hauler</u> Are the fish fit for travel? Major injuries, diseases are absent. Fish are not moribund; how are these aspects assessed?	Yes Visual	Yes Visual	Yes Visual
		<u>Information provided by the farm to the hauler</u> What is the length of feed deprivation; how many degree days? Is the feed deprivation sufficient to clear the gut? Are there other methods used to prepare the fish for transport?	Yes Feed deprivation in winter 1 week (at 4-6 ˚C). During Easter always food in the ponds, as it is a natural system. Yes in winter No at Easter No	Yes In some regions fish are not fed in a pond, as it is a natural system. Duration fasting depends on region. Yes No	Yes Feed deprivation in winter 5 days. Yes No
		Is the transport planned by the hauler? Is there a protocol available? Is a vehicle designed for this purpose? Is the vehicle maintained and cleaned prior to transport?	Yes Yes Yes Yes Not known	Yes Yes Yes Yes Not known	Yes Yes Yes Yes Not known

Means of transport	Life stage of the selected fish species	Transport practice	Poland (mostly during winter) CoD Market share 100%	Czech Republic (mostly during winter) National legislation and Code of practices market share 100%	Germany National legislation and protocols market share 100%
		What it the age of the vehicle? Are the post-transport activities described (receipt of fry/smolt at farm for on-growing or marketable fish at abattoir)? Specify.	Yes, control of water quality in concrete tanks.	Yes, control of water quality in concrete tanks.	Yes, at slaughterhouse fish kept in waiting pond for 5-7 days to remove off flavour. Oxygenated water. T and O_2 monitored.
		Crowding in holding tank or pond? Crowding practices inclusive of total duration of crowding. Monitoring of oxygen levels during crowding? Skill of personnel	Water level is decreased in pond. Fish are gathered in so-called catch pit and moved through pipes to a canal. Screens are used in the canal to herd fish. No Trained	Water level is decreased in pond. Fish are gathered in deeper part of the pond. No Trained	Water level is decreased in pond. Fish are gathered in deeper part of the pond. Yes Trained
		Which type of equipment is used to take fish out of the holding tank/cage, e.g. fully automated? e.g. brailing or pumping? Specify pump height and speed. Is it fully automated? Specify the routines for maintaining good water quality for duration of transfer.	Net Not applicable; no pump used. Manually During summer 5 minutes	Net is used to fill metal box with water with fish. Manually 5-10 s	Net is used to fill baskets with fish. Manually 10 s to 2 minutes

Means of transport	Life stage of the selected fish species	Transport practice	Poland (mostly during winter) CoD Market share 100%	Czech Republic (mostly during winter) National legislation and Code of practices market share 100%	Germany National legislation and protocols market share 100%
		Are the fish out of water? Length of time out of water? Are fish injured due to faulty constructions/fittings? Skill of personnel. Operation of equipment, is it according to manufacturer's recommendation?	maximum May happen Trained. Yes	May happen Staff trained. Yes	May happen Staff trained. Yes
		Loading the transport vehicle. Which type of equipment is used? Is it fully automated? e.g. brailing or pumping? Specify pump height and speed. Specify the routines for maintaining good water quality for duration of loading. Handling out of water? Length of time out of water. Skill of personnel. Operation of equipment, is it according to manufacturer's recommendation?	Net Manually Oxygenation of tank on truck During summer 5 minutes maximum. Gentle handling Trained. Yes	Net and metal box with water Manually Oxygenation of tank on truck 5-10 s Trained. Yes	Basket Manually Usually Oxygenation of tank on truck 10 s to 2 minutes Trained. Yes
		Specify the duration of transport in relation to means of transport used. Is sedation or anaesthesia applied during transport? Specify the routines for maintaining good water quality	1-3 h No Insulated truck, T, pH and O_2	0.5- 12 h No Insulated truck, T, pH and O_2	1 h To Poland it can be > 8 h. No Insulated truck, No monitoring

Means of transport	Life stage of the selected fish species	Transport practice	Poland (mostly during winter) CoD Market share 100%	Czech Republic (mostly during winter) National legislation and Code of practices market share 100%	Germany National legislation and protocols market share 100%
		for duration of transport. Which water quality parameters are monitored during transport? Are stops made to change transport water? Are the fish observed during transport; how? Skill of personnel. Operation of vehicle for transport, is it according to manufacturer's recommendation?	No Probably not Trained Yes	No Probably not Trained Yes	of water quality No. Yes if duration transport is ≥ 8 h. Probably not Trained Yes
		Specify the percentage of transports that operate with closed systems. Specify available equipment for water quality maintenance in closed systems Specify Monitoring of water quality parameters in closed systems.	100% Oxygenation Not sure if pH, T and O2 are always measured	100% Oxygenation T and O2 are measured	100% Usually Oxygenation No monitoring of water quality
		Unloading the transport vehicle. Which type of equipment is used? Is it fully automated? e.g. brailing or pumping? Specify pump height and speed. Specify the routines for maintaining good water quality for duration of unloading. Handling out of water? Length of time out of water. Skill of personnel. Operation of equipment, is it according to	Gravity No pump Tanks oxygenated Not applicable Trained. Yes	Gravity No pump Tanks oxygenated Not applicable Trained. Yes	Gravity Tanks. Water usually oxygenated. Not applicable Trained. Yes

Means of transport	Life stage of the selected fish species	Transport practice	Poland (mostly during winter) CoD Market share 100%	Czech Republic (mostly during winter) National legislation and Code of practices market share 100%	Germany National legislation and protocols market share 100%
		manufacturer's recommendation?			

10.2.5. SEA TRANSPORT

With regard to transport by well-boat, an open single pass flow through system or closed haul system can be used. Transport by truck is only possible with a closed system, and this may result in too high levels of carbon dioxide (King, 2009) and TAN (Total ammonia nitrogen, i.e. the sum of NH_3 and NH_4^+ concentrations) in the water.

The choice of an open or a closed system for sea transport depends upon whether there are bio-security issues associated with the fish itself, local regulations, or risks of contamination with fish pathogens along the transport route (Rosten and Kristensen, 2011).

Studies on transport of Atlantic salmon smolt revealed no negative impact on their welfare when a well-boat with an open system was used (Nomura et al., 2009).

With regard to marketable Atlantic salmon and smolts, studies performed by Erikson *et al.* (1997) and Iversen et al (2005) revealed that loading the well-boat is stressful for the fish. It should be noted that cortisol levels during transportation of smolts in open system well-boats returned to normal during transportation (Iversen et al., 2005). Only when transportation took place during rough weather – which could be considered a stressor – plasma cortisol levels remained elevated in smolts (Iversen et al., 2005).

In a report of the Norwegian Scientific Committee for Food Safety (VKM, 2008) the following recommendations were made regarding closed transportation of salmon fingerlings and smolts:

> *… the concentration of CO_2 should be below 20 mg/l. A lowering of the water temperature during transportation can reduce the impact of several factors on fish physiology and welfare. The temperature reduction must be carried out with great care and is recommended not to exceed 1.5 °C/hr. For Atlantic salmon and rainbow trout, the transportation temperature should not be below 6 °C. It is not possible to give an exact limit for the maximum transportation time in a closed system. This will depend on fish species, density, and temperature and water treatment in the transport unit.*

Transport by well-boat is performed in Norway, UK and Ireland for smolts and marketable Atlantic salmon. This means of transport is also used in Spain to transfer fry or juvenile sea bass and sea bream to cages for on-growing. An overview of transport methods by well-boat for the selected species is presented for Atlantic salmon smolts in Table 23, for sea bass and sea bream fry/fingerlings or juveniles in Table 25, and for marketable Atlantic salmon in Table 26.

10.2.6. AIR TRANSPORT

The use of helicopters to transport smolt is highly exceptional and therefore not included the detailed analysis. In Norway it is no longer used. In the UK, less than 1 % of the volume of smolts is transported by helicopter. In Ireland it is not used.

10.3. WELFARE DURING SLAUGHTER

10.3.1. BACKGROUND

Prior to a description of current practices for slaughter of the selected species per country, specific definitions are presented in the following box. Other definitions are presented in Section 4.2 :

Electrical stunning: The immediate induction of unconsciousness and insensibility in an animal or fish caused by the passage of an electrical current of sufficient strength through the brain.

EEG: Recording of electrical activity of the brain, using implanted or surface electrodes.

Source: Van de Vis et al., 2014

Visually evoked responses (VERs) or potentials (VEPs) and somatosensory evoked responses (SERs) on the EEG have been used in several fish species to determine the state of brain function following stunning (Van de Vis et al, 2016).

Reported studies reveal that a fish can be judged to be unconscious, using EEG registrations. Typical changes in the EEG, including evoked responses, need to occur due to the application of a stunning method for an unequivocal assessment of the level of brain function in fish to determine whether or not the fish are effectively stunned. In a commercial setting registration of EEGs and electrocardiograms (ECGs) is not possible. Here, observation of behaviour has to be used. It should be noted that behavioural measures have to be interpreted with caution (Van de Vis et al., 2014). Ineffective electrical stunning can be very painful and paralysis may occur without loss of consciousness. Also as a result of exhaustion or low body temperature due to chilling, a conscious fish may not be able to show spontaneous behaviour and responses.

Unless it is stated explicitly a stunning method has not been assessed by registration of EEG data in the fish species concerned. However, this statement does not imply that all stunners used, which fall under the category of the one assessed by EEGs (e.g. electrical stunning), render fish unconscious immediately. The proposed approach to assess stunning and killing by registration of EEGs is beyond the OIE standards.

An overview of stunning and killing methods for the selected species in this study is presented in the following sub-sections. These are followed by a series of tables presenting overviews of stunning and killing methods.

10.3.2. ISSUES FOR REVIEW OF STUNNING AND KILLING METHODS

We evaluated current practices for slaughtering of Atlantic salmon, gilthead sea bream, sea bass, freshwater rainbow trout and common carp, using the OIE standards (Table 7) as bench mark. An overview of this assessment is presented in Table 29 for Atlantic salmon, Table 30 for sea bass and sea bream, Table 31 for rainbow trout, and Table 32 for common carp.

Table 29. Overview of stunning and killing at abattoirs or farms used for Atlantic salmon

Stunning and killing practice	Norway (GMP at companies) Market share 95%	United Kingdom RSPCA Assured (90%*)	Ireland (Market share 100% Salmon Handbook) Carbon dioxide stunning still used.
Is there a contingency plan for all phases of stunning and killing? Is there a backup system in case of mis-stuns?	Yes Yes	Yes, a priest should be available in case of failure of the stunner. Yes	Yes not specified
Routines for maintaining good water quality in holding tanks/pens. Duration of holding fish prior to commencing slaughter.	Monitoring T, pH and O_2. Oxygenation is possible. Maximum up to 1-6 days	Waiting cages not used in the UK	Waiting cages not used in Ireland
Logistics of handling procedures. Are fish consecutively handled to ensure that they proceed rapidly to stunning and killing or are they handled intermittently?	Consecutively	Consecutively	Consecutively
Duration of holding fish prior to commencing slaughter; duration feed deprivation at an abattoir or farm. Specify the reason when the holding the fish exceeds 6 h prior to commencing the process of slaughter.	Yes, can be up to 1 to 6 days for reasons of logistics and product quality.	Not applicable	Not applicable
Crowding in holding tank or cage? Crowding practices inclusive of total duration of crowding. Monitoring of oxygen levels during crowding?	Standards for crowding: gentle. Duration 1-2 h. Oxygen in some cases controlled by oxygenation	No waiting cages in the UK.	No waiting cages in Ireland
Which type of equipment is used to take fish out of the holding tank/cage, e.g. fully automated? E.g. brailing or pumping? Are fish injured due to faulty constructions/fittings?	Vacuum pump	Vacuum pump	Vacuum pump or brail
Are conscious fish subjected to any treatment to make the animals calm or reduce their metabolic rate? Specify the method used.	Live chilling (T= 8 °C 45 minutes) prior to stunning	Live chilling in the well-boat. (drop in T 1.5 °C/h maximum and limit T 4-6 °C)	No.
Is a stunning method applied?	Percussion (market share approximately 50%), electrical stunning	For RSPCA Assured only percussion is allowed.	Percussion (market share 92-93%). The industry is moving

Stunning and killing practice	Norway (GMP at companies) Market share 95%	United Kingdom RSPCA Assured (90%*)	Ireland (Market share 100% Salmon Handbook) Carbon dioxide stunning still used.
	after dewatering (market share approximately 50%), live chilling combined with CO_2 (market share < 5%). Less than 5% of all fish is stunned by percussion at a large vessel (mobile abattoir) that sails to farms.	Market share: 95% percussion and 5% electrical stunning Of all stunned fish 80% is stunned at an abattoir and 20% at a large vessel (mobile abattoir) that sails to farms.	away from carbon dioxide stunning, which market share is still 7-8%. Stunning is performed on board of a vessel, a raft next to the sea cages or a pier.
Transfer into stunner. Which type of equipment is used? Handling out of water? Length of time out of water. Is orientation of the fish required? Are fish injured or subjected to sub-optimal conditions for stunning due to faulty constructions/fittings?	Pump Yes, for electrical stunning Not specified Yes, for percussion and electrical stunning after dewatering. For 25-30% of electrical stunners after dewatering fish are orientated (they enter head-first). This percentage will increases due to replacement of 10 year old stunners by new equipment with a device to orientate fish prior to stunning.	Pump Yes Limit 15 s Yes, for percussion. Not for electrical stunning in water	Pump Yes Not specified Yes, for percussion.
Which specifications are used for stunning? Do checks of state of consciousness occur? Skill of personnel	Voltage and amperage for electrical stunning and air pressure for percussion. Yes Trained	Voltage and amperage for electrical stunning and air pressure for percussion Yes Trained	Voltage and amperage for electrical stunning and air pressure for percussion Yes Trained
Is a killing method applied? Or is the stun irreversible?	Gill-cutting..	RSPCA Assured bleeding within 10 s after percussion Gill-gutting after electrical stunning	Gill-cutting
No exceedance of established time interval between stunning and application of killing method?	No. In practice approximately 6 s	No. Data on duration stun-bleeding interval	No, within 3 s.

Stunning and killing practice	Norway (GMP at companies) Market share 95%	United Kingdom RSPCA Assured (90%*)	Ireland (Market share 100% Salmon Handbook) Carbon dioxide stunning still used.
		not available for electrical stunning.	
Specify killing method (e.g. gill cut, chilling or other method)? Skill of personnel	Gill-cut for electrical stunning Trained staff	Gill-cut for electrical stunning Trained staff	Gill-cut for electrical stunning Trained staff

Table 30. Overview of stunning and killing gilthead sea bream and sea bass at farms

Stunning and killing practice	Greece Market share approximately 100% National standard Agro 4.1	Spain Market share 100%	Italy Market share 90% Code of practice API
Is there a contingency plan for all phases of stunning and killing? Is there a backup system in case of mis-stuns?	Yes	Yes	Yes
Routines for maintaining good water quality in holding tanks/pens. Duration of holding fish prior to commencing slaughter.	Same as for on-growing in cages	Same as for on-growing in cages	Same as for on-growing
Logistics of handling procedures. Are fish consecutively handled to ensure that they proceed rapidly to stunning and killing or are they handled intermittently?	Electrical stunning is still experimental, so answer is no.		
Duration of holding fish prior to commencing slaughter; duration feed deprivation at an abattoir or farm. Specify the reason when the holding the fish exceeds 6 h prior to commencing the process of slaughter.	Not applicable 40 degree days	Not applicable 48 h	Not applicable 50 degree days
Crowding in holding tank or cage? Crowding practices inclusive of total duration of crowding. Monitoring of oxygen levels	Crowded in cage 20-40 minutes Oxygen levels measured	Crowded in cage 20-40 minutes No	Crowded in cage 15-30 minutes Or fish kept in extensive aquaculture are capture with a net in a lagune.

Stunning and killing practice	Greece Market share approximately 100% National standard Agro 4.1	Spain Market share 100%	Italy Market share 90% Code of practice API
during crowding?	seldom.		No, only in flow-through tanks
Which type of equipment is used to take fish out of the holding tank/cage, e.g. fully automated? E.g. brailing or pumping? Are fish injured due to faulty constructions/fittings?	Brail and experimental electrical stunning pumping. No	Net No	Brail or pumps for bream. Pump or net in case of flow-through tank. For cages and lagune net. No
Are conscious fish subjected to any treatment to make the animals calm or reduce their metabolic rate? Specify the method used.	No	No	No
Is a stunning method applied?	No. Electrical stunning is experimental.	no	no
Transfer into stunner. Which type of equipment is used? Handling out of water? Length of time out of water. Is orientation of the fish required? Are fish injured or subjected to sub-optimal conditions for stunning due to faulty constructions/fittings?	Not applicable Yes, for net For net 60-120 s	Not applicable	Not applicable Yes 5-20 s
Which specifications are used for stunning? Do checks of state of consciousness occur? Skill of personnel	Not applicable trained	Not applicable trained	Not applicable trained
Is a killing method applied? Or is the stun irreversible?	Live chilling	Live chilling	Live chilling followed by gill cutting.
No exceedance of established time interval between stunning and application of killing method?	Not applicable, for killing without stunning.	Not applicable	Not applicable
Specify killing method (e.g. gill cut, chilling or other method)? Skill of personnel	Chilling in ice slurry	Live chilling	Live chilling followed by gill cutting.

Table 31. Overview of stunning and killing of freshwater rainbow trout at abattoirs and farms

Stunning and killing practice	Denmark (Market share 100% National legislation and protocols)	France (National legislation and protocols market share100%)	Italy (National legislation and protocols market share 100%)	Poland (Market share 100%) CoD and GMP
Is there a contingency plan for all phases of stunning and killing? Is there a backup system in case of mis-stuns?	Yes Not known	Yes Not known	Yes, probably.	Yes, probably.
Routines for maintaining good water quality in holding tanks. Duration of holding fish prior to commencing slaughter.	Flow of water oxygenation 1-3 days	Flow of water oxygenation < 7days	Flow of water oxygenation Not known	No holding tanks used for portion size. For large trout holding tank use
Logistics of handling procedures. Are fish consecutively handled to ensure that they proceed rapidly to stunning and killing or are they handled intermittently?	Pumped to commence slaughter. Intermittently.	Mostly netted to commence slaughter. Not known	Pumped or netted to commence slaughter. Not known	Gravity to unload truck Not known
Duration of feed deprivation at an abattoir or farm. Specify the reason when the holding the fish exceeds 6 h prior to commencing the process of slaughter.	1-3 days Logistics. Recovery from transport for reasons of product quality.	< 7 days Logistics. Recovery from transport for reasons of product quality.	Not known Logistics. Recovery from transport for reasons of product quality.	O days for portion size trout. Large trout kept in tanks; duration not known
Crowding in holding tank or cage? Crowding practices inclusive of total duration of crowding. Monitoring of oxygen levels during crowding?	Tank. Lower water level and pump fish. Duration not known.	Tank. Lower water level and pump fish. Duration not known.	Tank. Lower water level and pump fish. Duration not known.	No crowding. . Large trout netted from tank. Crowding may be used
Which type of equipment is used to take fish out of the holding tank, e.g. fully automated? E.g. brailing or pumping? Are fish injured due to faulty	Pump Yes, automated May happen	Mostly a net Yes/no May happen	Pump/net Yes/no May happen	No holding tank used for portion size. For large trout holding tank is used. Net or brail is used

Stunning and killing practice	Denmark (Market share 100% National legislation and protocols)	France (National legislation and protocols market share100%)	Italy (National legislation and protocols market share 100%)	Poland (Market share 100%) CoD and GMP
constructions/fittings?				May happen
Are conscious fish subjected to any treatment to make the animals calm or reduce their metabolic rate? Specify the method used.	No	No	No	No
Is a stunning method applied?	Asphyxia in ice (30% market share) Electrical stunning in water (70% market share); equipment probably not purchased from major manufacturers. Therefore not known whether stunning is effective	CO_2 stunning for large fish, as electrical stunning is not effective. Electrical stunning in water; equipment probably not purchased from major manufacturers. Therefore not known whether stunning is effective. Sometimes conscious fish placed in ice water and subsequently exposed to electricity for stunning. A manually applied blow to the head	Electrical stunning in water; equipment probably not purchased from major manufacturers. Therefore not known whether stunning is effective	No. > 50% of the fish are exposed to asphyxia in ice/ice slurry during transport. The portion size conscious fish are exposed to asphyxia. Large trout are beheaded without stunning them first.
Transfer into stunner. Which type of equipment is used? Handling out of water? Length of time out of water. Is orientation of the fish	Electrical stunning in water No. Pump is used No May happen	Mostly a net Yes for netting. Not known No May happen	Pump or net Yes for netting. Not known Probably not May happen	No stunning method used Yes for netting large trout No

Stunning and killing practice	Denmark (Market share 100% National legislation and protocols)	France (National legislation and protocols market share100%)	Italy (National legislation and protocols market share 100%)	Poland (Market share 100%) CoD and GMP
required? Are fish injured or subjected to sub-optimal conditions for stunning due to faulty constructions/fittings?				May happen
Which specifications are used for stunning? Do checks of state of consciousness occur? Skill of personnel	For electrical stunning voltage and duration exposure Not known trained	For electrical stunning voltage and duration exposure. Not known trained	For electrical stunning voltage and duration exposure.	Not applicable
Is a killing method applied? Or is the stun irreversible?	Yes, for electrical stunning	Yes, for electrical stunning	Not known.	Only for conscious large trout.
No exceedance of established time interval between stunning and application of killing method?	Not known	Not known	Not known	Not applicable
Specify killing method (e.g. gill cut, chilling or other method)? Skill of personnel	Throat cut Trained	Large fish are bled. All fish are gutted Trained		Beheading of large trout Trained

Table 32. Overview of stunning and killing common carp at abattoirs or farms

Stunning and killing practice	Poland (25%, slaughtered;75 % is sold live) CoD Market share 100%	Czech Republic (approximately15%, slaughtered; 85 % is sold live) National legislation market share 100%	Germany National legislation and protocols market share 100%
Is there a contingency plan for all phases of stunning and killing? Is there a backup system in case of mis-stuns?	Not specified in CoD Not specified in CoD	Not specified Not specified	Yes Yes

Stunning and killing practice	Poland (25%, slaughtered;75 % is sold live) CoD Market share 100%	Czech Republic (approximately15%, slaughtered; 85 % is sold live) National legislation market share 100%	Germany National legislation and protocols market share 100%
Routines for maintaining good water quality in holding tanks. Duration of holding fish prior to commencing slaughter.	Oxygenation. Slaughtered on the day of arrival.	Slaughter starts immediately during unloading of the truck. Very few slaughterhouses use holding tanks, If tanks are used, oxygenation of water is applied.	Oxygenation of ponds. 5-7 days to remove off flavour.
Logistics of handling procedures. Are fish consecutively handled to ensure that they proceed rapidly to stunning and killing or are they handled intermittently?	For electrical stunning and percussive stunning (manually) handled intermittently.	During unloading of the truck fish are transferred to equipment for electrical stunning Not specified	For electrical stunning and percussive stunning (manually) handled intermittently.
Duration of holding fish prior to commencing slaughter; duration feed deprivation at an abattoir or farm. Specify the reason when the holding the fish exceeds 6 h prior to commencing the process of slaughter.	5-7 days. Logistics. Removal of off flavour for product quality reasons.	Not applicable. Not applicable.	Maximum 5-7 days. Product quality (removal of off flavour)
Crowding in pond? Crowding practices inclusive of total duration of crowding. Monitoring of oxygen levels during crowding?	At a slaughterhouse ponds are present for temporarily storage. Standard procedure at farm	At a few slaughterhouse tanks are present for temporarily storage. Not further specified. Not applicable	At a slaughterhouse ponds are present for temporarily storage. T and O_2 are monitored.
Which type of equipment is used to take fish out of the holding tank/cage, e.g. fully automated? E.g. brailing or pumping? Are fish injured due to faulty constructions/fittings?	Nets Not automated May happen.	Not applicable May happen	Pump/net Automated/manually May happen
Are conscious fish subjected to any treatment to make the animals calm or reduce their metabolic rate? Specify the method used.	No	No	No
Is a stunning method applied?	Percussion is preceded by air exposure for 1-10	Electrical stunning in water; equipment	Manual percussion Electrical stunning in

Stunning and killing practice	**Poland (25%, slaughtered;75 % is sold live) CoD Market share 100%**	**Czech Republic (approximately15%, slaughtered; 85 % is sold live) National legislation market share 100%**	**Germany National legislation and protocols market share 100%**
	minutes Electrical stunning in water; equipment probably not purchased from major manufacturers. Therefore not known whether stunning is effective.	probably not purchased from major manufacturers. Therefore not known whether stunning is effective.	water; equipment probably not purchased from major manufacturers. Therefore not known whether stunning is effective. At slaughterhouse electrical stunning is the dominant method.
Transfer into stunner. Which type of equipment is used? Handling out of water? Length of time out of water. Is orientation of the fish required? Are fish injured or subjected to sub-optimal conditions for stunning due to faulty constructions/fittings?	Net Yes. It can be up to 10 minutes. No, no instrumental method No	Net Yes. Not specified No No	Netting Yes. Up to 2 minutes
Which specifications are used for stunning? Do checks of state of consciousness occur? Skill of personnel	For electrical stunning voltage and amperage as specified by manufacturer Not specified in CoD Trained.	For electrical stunning voltage and amperage as specified by manufacturer Not specified in legislation. Trained.	For electrical stunning conductivity of the water and duration exposure Yes, legislation requires this for both stunning methods. Trained.
Is a killing method applied? Or is the stun irreversible?	Gill-cutting or decapitation	No. However, electricity does not kill carp.	Gill-cut after electrical stunning or a blow to the head
No exceedance of established time interval between stunning and application of killing method?	Probably not. Immediate killing after electrical stunning.	Not applicable as industry considers application of electricity to be sufficient for stun and kill. From scientific literature it is known that carp cannot be killed by	Immediate application of killing method is recommended..

Stunning and killing practice	**Poland (25%, slaughtered;75 % is sold live) CoD Market share 100%**	**Czech Republic (approximately15%, slaughtered; 85 % is sold live) National legislation market share 100%**	**Germany National legislation and protocols market share 100%**
		electricity.	
Specify killing method (e.g. gill cut, chilling or other method)? Skill of personnel	Not known Trained.	Not applicable. Trained.	Gill-cut or blow the head Trained

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10.5. THE EXTENT THAT FISH WELFARE ISSUES ARE ADDRESSED OR REMAIN UNRESOLVED

Based on the literature search and the survey carried out, our findings on the issues that remain unresolved are presented below. It should be noted that we addressed whether current practices during transport and slaughter adhere to the OIE standards. An audit of compliance with OIE standards in a commercial setting in the selected EEA Member States was not part of this study.

The scope of the OIE standards for transport is to minimise the effect of transport on the welfare of farmed fish.

10.5.1. TRANSPORT

Current practices used for transport of fry/fingerling/juveniles and marketable fish were assessed using the OIE standards as benchmark. The assessment of current transport practices is presented in Tables 22-28. In Table 33 the level of adherence to the OIE standards is presented.

These data show that for transport of marketable common carp the OIE standards are not fully met in Poland and Germany. The reason is that a contingency plan and monitoring of water quality are major issues for control of transport. In the text below current practices for the selected fish species and countries are briefly discussed.

Table 33: Summary of current transport methods indicating adherence to OIE standards

Fish species	Country	Transport of fry/ fingerlings/ juveniles/ smolts		Transport of marketable fish	
		Outcome	Explanation	Outcome	Explanation
Atlantic salmon	Norway	✓ OIE	standards met	✓ OIE	standards met
	United Kingdom	✓ OIE	standards met	✓ OIE	standards met
	Ireland	✓ OIE	standards met	✓ OIE	standards met
Common carp	Poland	n.a.		partly OIE	No contingency plan. Water quality not monitored
	Czech Republic	n.a.		✓ OIE	standards are met
	Germany	n.a.		partly OIE	No contingency plan
Rainbow trout	Denmark	n.a.		✓ OIE	standards met
	France	n.a		✓ OIE	standards met
	Italy	n.a.		✓ OIE	standards met
	Poland	n.a.		✓ OIE	standards met
European sea bass	Greece	✓ OIE	standards met	n.a.	
	Spain	✓ OIE	standards met	n.a.	
	Italy	✓ OIE	standards met	n.a.	
Gilthead sea bream	Greece	✓ OIE	standards met	n.a.	
	Spain	✓ OIE	standards met	n.a.	
	Italy	✓ OIE	standards met	n.a.	

✓ OIE - likely that the OIE standards are achieved
× OIE - likely that the OIE standards are not achieved
partly OIE - not all OIE standards are met[45]
n.a. - not applicable (only one type of transport was subject selected for this study)

10.5.1.1. Atlantic salmon

Road transport

Smolts
Transport of smolts in Norway, UK and Ireland are performed in accordance with OIE standards, as shown by data obtained from literature, focus groups and targeted stakeholder interviews

Sea transport

Marketable fish
Transport of marketable fish in Norway, UK and Ireland meets OIE standards.

[45] Note that for transport of farmed fish, there are many criteria regarding adherence to OIE standards. Hence it is possible that OIE standards may be partly met. This is distinct from OIE standards for slaughter (see Table 34), where it is more of a binary (yes/no) judgement.

Air transport

Not considered –it is an exception.

10.5.1.2. Common Carp

Road transport

Marketable fish

Transport of marketable fish in Germany is partly in accordance with OIE standards; a contingency plan is not available. In Poland a contingency plan is not available and water quality is not monitored and, therefore, the OIE standards are partly met.

10.5.1.3. Rainbow trout

Road transport

Marketable fish

Transport of marketable fish in Denmark, Italy, France and Poland is performed in accordance with OIE standards.

10.5.1.4. European sea bass and gilthead sea bream

Road transport

Fry/fingerlings/juveniles
Transport of fry/fingerlings/juveniles in Greece, Spain and Italy is performed in accordance with OIE standards.

Sea transport

Fry/fingerlings/juveniles
Transport of fry/fingerlings/juveniles in Spain by well-boat meets OIE standards.

Marketable fish
No live transport of marketable fish takes place in the target countries.

10.5.2. Slaughter

The outcome of the assessment of current slaughter practices is presented in Table 34. The outcome is based on the assessment of all current slaughter practices, which is presented in Tables 29-32.

The OIE standards for stunning and killing are formulated on the general principle that farmed fish should be stunned before killing, and the stunning method should ensure immediate and irreversible loss of consciousness. If stunning is not irreversible, fish should be killed before consciousness is recovered. In addition, the OIE standards describe methods that should not be used for killing of conscious fish.

For slaughter of Atlantic salmon, the OIE standards are met in the UK. They may or may not be met in Norway and Ireland, depending on the method used.

For slaughter of carp in Poland, the Czech Republic and Germany, the OIE standards may or may not be met, depending on the method and the equipment used.

For slaughter of trout in Poland, the OIE standards are not met. In Denmark, France and Italy, they may or may not be met, depending on the method and the equipment used.

For sea bass and sea bream in Greece, Spain and Italy, the OIE standards for slaughter are not met.

An explanation for these findings is presented in Table 34 and the following paragraphs.

Table 34 : Summary of current slaughter methods indicating adherence to OIE standards

Fish species	Country in study	Slaughter	
		Outcome	Explanation
Atlantic salmon	Norway	+/- OIE	Percussion (standards are met). Dry electrical stunning: only 25-30% oriented, though increasing (standards are met for the 25-30%). Electrically stunned fish killed by gill-cut (standards not met), or by percussion or decapitation (standards met). Live chilling with CO_2 still used (standards not met).
	United Kingdom	✓ OIE	Standards are met
	Ireland	+/- OIE	Percussion. CO_2 stunning still used for 7-8 %
Common carp	Poland	+/- OIE	Manual percussion. Electrical stunner not from major producer
	Czech Republic	+/- OIE	Electrical stunner not from major producer and no killing method applied
	Germany	+/- OIE	Manual percussion. Electrical stunner not from major producer
Rainbow trout	Denmark	+/- OIE	Electrical stunner not from major producer. Also asphyxia in ice
	France	+/- OIE	Manual percussion. However, CO_2 stunning and chilling in ice water followed by electrical stunning are also used.
	Italy	+/- OIE	Electrical stunner not from major producer
	Poland	× OIE	Asphyxia in ice slurry on a truck or at a farm or abattoir.
European sea bass	Greece	× OIE	Asphyxia in ice or ice slurry
	Spain	× OIE	Asphyxia in ice or ice slurry
	Italy	× OIE	Asphyxia in ice or ice slurry
Gilthead sea bream	Greece	× OIE	Asphyxia in ice or ice slurry
	Spain	× OIE	Asphyxia in ice or ice slurry
	Italy	× OIE	Asphyxia in ice or ice slurry

✓ OIE - likely that the OIE standards are achieved
× OIE - likely that the OIE standards are not achieved
+/- OIE - OIE standards may be achieved, depending on the method and the equipment used[46]

10.5.2.1. Atlantic salmon

For the UK, OIE standards are met for Atlantic salmon. They may or may not be met for slaughter in Norway and Ireland.

In Norway the OIE standards for percussion of salmon are met. For electrical stunning after dewatering, 25-30 % of the fish are oriented prior to stunning, which is in accordance with OIE

[46] Compared to the transport of farmed fish, it is more of a binary (yes/no) assessment whether OIE standards for slaughter are adhered to at a particular facility. The +/- indicator therefore refers more to the number of facilities where standards are or are not met.

standards; and the percentage is increasing. For killing of electrically stunned salmon the standards are met when decapitation or percussion is applied as killing method. Live chilling with CO_2 is still used in Norway, but is stressful and does not induce immediate loss of consciousness (Erikson, 2011); therefore, it does not meet the OIE standards. However, live chilling with CO_2 will be phased out.

In Ireland, carbon dioxide stunning is still used for 7-8 % of salmon slaughtered and this does not meet OIE standards. Percussion in Ireland adheres to OIE standards.

With regard to standards beyond OIE, implementation of stunning and killing methods should be based on EEG registration, as advised by EFSA (2013). For electrical stunning after dewatering and percussive stunning, specifications to achieve and immediate stun in Atlantic salmon have been published in peer-reviewed journals. In one of these studies, it was shown that gill cutting of stunned Atlantic salmon was not an effective killing method. Recovery can be prevented by decapitation or percussion of the electrically stunned salmon.

10.5.2.2. Common carp

A manually applied blow to the head can meet OIE standards when it is applied instantaneously after the carp is taken out of the water. However, the blow is preceded by an exposure to air for 10 minutes (maximum) in Poland. An instantaneous application of a blow to the head will reduce stress in carp. In Germany, a blow to the head is applied instantaneously after taking the fish out of the water, which adheres to OIE standards.

EEG data for percussive stunning were published for an experimental percussive stunner. However, manually applied percussion for carp has not been assessed by registration of EEGs. Regarding electrical stunning of carp in Poland, Czech Republic and Germany, the status is similar to that of percussion. Moreover, equipment used for electrical stunning in these countries may not be manufactured by one of the major producers. It is therefore not known whether electrical stunning induces an immediate loss of consciousness in carp in these countries.

10.5.2.3. Rainbow trout

Slaughter of trout in Denmark and Italy may meet OIE standards with respect to electrical stunning. However, the equipment used may not be manufactured by one of the major producers. Hence, it cannot be established whether electrical stunning induces immediate loss of consciousness. When correctly applied, manual percussion in France adheres to the OIE standards.

Asphyxia in ice in Denmark and Poland is not in accordance with OIE standards. Carbon dioxide stunning, and exposure to ice water prior to electrical stunning in France do not adhere to OIE standards. In the past, electrical stunning of rainbow trout was tested in Poland, but was abandoned due to carcass damage.

10.5.2.4. European sea bass and gilthead sea bream

Asphyxia in ice of both sea bass and sea bream does not adhere to OIE standards. However, according to a national code of practice in Spain, published in November 2016, the use of ice or an ice slurry to kill bass or bream (by asphyxiation) is allowed. Electrical stunning of both species is still in an experimental stage in Greece.

10.5.3. Multiannual plans for aquaculture development in EU Member States

In 2014-2015, EU Member States developed Multiannual National Strategic Plans for the promotion of sustainable aquaculture. Table 35 gives a brief summary of the Multiannual National Plans for aquaculture development and National Operational Programmes under the European Maritime and Fisheries Fund. The table indicates whether fish welfare was addressed as an issue.

Table 35: Overview of multiannual national plans for aquaculture development

Fish species	Country in study	Fish welfare addressed
Atlantic salmon	Norway United Kingdom Ireland	Not applicable as Norway is not an EU Member State Yes, sea lice is addressed. Yes, sea lice and organic aquaculture are addressed
Common carp	Poland Czech Republic Germany	No No No
Rainbow trout (Large (L) and Portion (P))	Denmark France Italy Poland	Yes, organic aquaculture is addressed. No Yes No
European sea bass	Greece Spain Italy	Yes, organic aquaculture is addressed. Yes Yes
Gilthead sea bream	Greece Spain Italy	Yes, organic aquaculture is addressed. Yes Yes

11. SOCIO-ECONOMIC ANALYSIS

This chapter presents an analysis of the socio-economic aspects of the European aquaculture sector

11.1. AQUACULTURE PRODUCTION, TRANSPORT AND SLAUGHTER

11.1.1. AQUACULTURE PRODUCTION IN EEA STATES

Table 36 shows the national production from aquaculture of fish, crustaceans, molluscs and other aquatic organisms in the 19 main aquaculture producing EEA States for the years 2009 - 2013. Output from hatcheries and nurseries is not included in this section and in those following on individual species.

These 19 States account for 99 % of EEA aquaculture production.

Between 2009 and 2013, total EEA production from aquaculture increased from 2 271 to 2 473 thousand tonnes live weight, a rise of 8.9 %.

Norway is by far the largest EEA aquaculture producer with a share of over 50 % in 2013. Norwegian production increased by almost 30 % between 2009 and 2013. Spain is the second largest EEA producer by quantity. The United Kingdom (UK) overtook France to become the third largest producer in 2013.

Table 36. Aquaculture production in 19 EEA States, 2009-2013 (1 000 tonnes live weight)*

EEA State	2009	2010	2011	2012	2013	Change 2009-2013	Share of EEA total, 2013
Norway	962	1 020	1 144	1 321	1 248	29.7%	50.5%
Spain	267	252	272	264	224	-16.1%	9.0%
United Kingdom	197	201	199	206	203	3.4%	8.2%
France	234	*225*	207	*205*	201	-14.2%	8.1%
Italy	162	153	164	*163*	*163*	0.1%	6.6%
Greece	122	121	111	111	114	-6.6%	4.6%
Netherlands	56	67	44	46	60	8.5%	2.4%
Denmark	35	*36*	*36*	35	*38*	7.3%	1.5%
Poland	37	31	29	32	35	-3.6%	1.4%
Ireland	48	46	44	36	34	-28.0%	1.4%
Germany	39	41	39	26	25	-35.0%	1.0%
Czech Republic	20	20	21	21	19	-3.6%	0.8%
Hungary	15	14	16	15	15	0.6%	0.6%
Finland	14	12	11	13	14	-0.1%	0.6%
Sweden	9	11	13	14	13	56.5%	0.5%
Bulgaria	7	8	6	6	12	80.8%	0.5%
Croatia	14	14	13	10	12	-15.5%	0.5%
Romania	13	9	8	*10*	*11*	-16.2%	0.4%
Portugal	7	8	9	10	10	49.6%	0.4%
Total 19 States	**2 255**	**2 290**	**2 386**	**2 544**	**2 451**	**8.7%**	**99.1%**
Total EEA	**2 271**	**2 306**	**2 403**	**2 563**	**2 473**	**8.9%**	**100.0%**

Source: FAO Global Fishery and Aquaculture Statistics, Version 2016.1.2. Figures in italics are forecasts
**Totals may vary slightly due to rounding*

Table 36 shows the percentage change in production between 2009 and 2013 in each of the 19 States. Of the 11 states selected for analysis by the study, Norway was the only one to show double digit growth (of 30 %) over the period.

11.1.2. AQUACULTURE PRODUCTION IN NON-EEA COUNTRIES

Table 37 shows the national production from aquaculture of fish, crustaceans, molluscs and other aquatic organisms from the major non-EEA producers for the years 2009 - 2013.

China is by far the largest producer of fish from aquaculture in the world with a global market share of nearly 60 % in 2013. Chinese production increased by 26 % from 45 to 57 million tonnes live weight between 2009 and 2013. Chile is the world's third largest producer behind China and Norway. Other major non-EEA producers are Turkey and Canada. In addition to China, the other three major non-EEA aquaculture producers all showed significant increases in production between 2009 and 2013.

European aquaculture accounts for just under 10 % of world production.

Table 37. Aquaculture production in selected non-EEA countries and by continent, 2009 - 2013 (1 000 tonnes live weight)

	2009	2010	2011	2012	2013	Change 2009-2013
Selected non-EEA Country						
China	45 279	47 830	50 173	53 943	57 113	26.1%
Chile	881	*713*	970	1 076	1 046	18.7%
Turkey	160	168	189	213	234	46.5%
Canada	156	162	169	183	170	9.1%
Continent						
Asia	66 686	71 327	75 447	82 342	89 378	34.0%
Americas	2 554	2 527	2 790	2 993	3 072	20.3%
Europe	2 519	2 546	2 661	2 855	2 768	9.9%
Africa	1 103	*1 424*	*1 538*	*1 646*	1 738	57.5%
Oceania	183	205	213	212	206	12.3%
World total	**73 046**	**78 029**	**82 649**	**90 049**	**97 162**	**33.0%**

Source: FAO Global Fishery and Aquaculture Statistics, Version 2016.1.2
Figures in italics are forecasts

11.1.3. VALUE OF AQUACULTURE PRODUCTION IN EEA STATES

Table 38 shows the value of fish, crustaceans, molluscs and other aquatic organisms produced from aquaculture in the 19 main aquaculture producing EEA States from 2009 - 2013.

The value of total EEA aquaculture production increased from USD 8 126 million in 2009 to USD 11 897 million in 2013, a rise of just over 46 %. Six EEA States account for almost 90 % of the 2013 total: Norway (58.0 %), UK (10.0 %), France (7.9 %), Greece (4.9 %), Italy (4.4 %) and Spain (4.3 %). Of these, Norway and UK showed significant growth over the period with the value of Norwegian production increasing by 92 %, whilst Italy showed a 21 % fall in value despite the production quantity remaining virtually the same.

Table 38. Value of aquaculture production from 19 EEA States, 2009 - 2013 (USD million)

EEA State	2009	2010	2011	2012	2013	Change 2009-2013	Share of EEA total, 2013
Norway	3 590	5 087	5 161	5 167	6 897	92.1 %	58.0 %
United Kingdom	781	800	1 056	947	1 191	52.6 %	10.0 %
France	959	871	927	881	941	-1.9 %	7.9 %
Greece	555	588	660	574	578	4.1 %	4.9 %
Italy	663	442	561	506	523	-21.1 %	4.4 %
Spain	520	521	572	494	510	-1.9 %	4.3 %
Netherlands	118	142	106	119	172	45.7 %	1.4 %
Ireland	141	150	174	164	152	8.0 %	1.3 %
Denmark	123	133	148	117	145	18.0 %	1.2 %
Poland	107	90	86	95	105	-1.2 %	0.9 %
Germany	127	126	120	94	103	-19.1 %	0.9 %
Portugal	47	63	81	69	73	53.5 %	0.6 %
Croatia	83	72	70	66	72	-13.6 %	0.6 %
Finland	56	55	60	49	65	15.6 %	0.5 %
Sweden	23	41	59	59	64	174.5 %	0.5 %
Czech Republic	55	54	62	54	50	-9.9 %	0.4 %
Hungary	38	37	42	39	35	-8.3 %	0.3 %
Bulgaria	24	26	19	20	35	46.8 %	0.3 %
Romania	24	26	22	24	30	24.9 %	0.2 %
Total 19 States	**8 035**	**9 325**	**9 986**	**9 537**	**11 741**	**46.1 %**	**98.7 %**
Total EEA	**8 126**	**9 432**	**10 108**	**9 654**	**11 897**	**46.4 %**	**100.0 %**

Source: FAO Global Fishery and Aquaculture Statistics, Version 2016.1.2

11.1.4. VALUE OF AQUACULTURE PRODUCTION IN NON-EEA COUNTRIES

Table 39 shows the value of aquaculture production in the four selected non-EEA countries and globally between 2009 and 2013.

China is by far the world's most important producer by production value, producing almost ten times the value of the second country, Chile. Chinese production value increased from 57 to 73 billion USD between 2009 and 2013, an increase of 28 %. The other three selected non-EEA countries also showed strong increases in the value of production of between 33 % and 58 %.

Globally, Asia produces 78 % of aquaculture by value and Europe 8 %.

Table 39. Value of aquaculture production in selected non-EEA countries and by continent, 2009 - 2013 (USD million)

	2009	2010	2011	2012	2013	Change 2009-2013
Selected non-EEA Country						
China	57 300	61 369	64 269	69 077	73 088	27.6 %
Chile	4 783	3 769	6 340	6 003	7 553	57.9 %
Canada	703	893	848	865	937	33.4 %
Turkey	616	709	764	901	906	47.1 %
Continent						
Asia	89 705	101 352	108 015	116 682	124 012	38.2 %
Americas	10 149	10 192	13 708	13 276	16 247	60.1 %
Europe	8 986	10 323	11 170	10 845	13 142	46.2 %
Africa	2 153	2 714	3 196	3 368	3 627	68.5 %
Oceania	791	1 156	1 263	1 456	1 439	82.0 %
World total	**111 784**	**125 737**	**137 352**	**145 628**	**158 469**	**41.8 %**

Source: FAO Global Fishery and Aquaculture Statistics, Version 2016.1.2

11.1.5. NUMBER OF AQUACULTURE PRODUCTION ENTERPRISES IN SELECTED EU MEMBER STATES

Figure 18 shows the number of aquaculture enterprises in selected EU Member States in 2013 as far as data are available from the STECF database (Norway is not included). In the case of Greece, more complete data is available for 2014.

The number of fish farms is split in three categories based on the number of employees. In all the EU Member States where data is available, the majority of fish farms have five or fewer employees.

In all EU Member States except the United Kingdom there was a small decrease in the number of enterprises between 2009 and 2013/14.

Spain and France have the greatest number of enterprises and, despite both being large EU producers, they have amongst the lowest production per enterprise. Of the EU Member States where STECF data is available, only Poland had a lower output per enterprise in 2013.

In contrast, Greece has the highest output per enterprise of those where data is available, followed by the United Kingdom, Denmark and Italy.

Data on the German aquaculture industry were absent in the STEC overview. Therefore, data on number of farms and farm size were retrieved from the German Federal Statistical Office. In 2016 the total number of farms was 5 952 and had a total production volume of 21 thousand tonnes. This results in an annual output of 3.5 tonnes/farm/year[47].

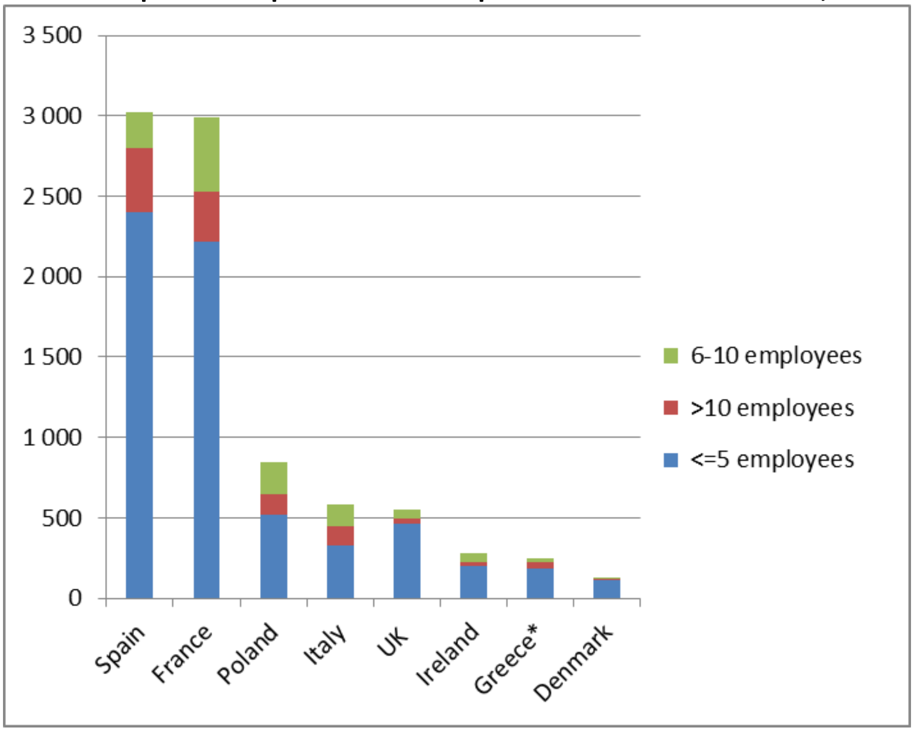
[47] https://www.destatis.de/DE/ZahlenFakten/Wirtschaftsbereiche/LandForstwirtschaftFischerei/Fischerei/Tabellen/AquaBetriebeMenge.html

Table 40. Average output of fish per enterprise in selected EU Member States

	National sales volume (tonnes)	Number of enterprises	Output per enterprise (tonnes)
Greece (2014)	118 080	248	476.1
UK (2013)	203 263	548	370.9
Denmark (2013)	46 297	130	356.1
Italy (2013)	153 944	587	262.3
Ireland (2013)	34 667	283	122.5
Spain (2013)	231 738	3 023	76.7
France (2013)	227 601	2 988	76.2
Poland (2013)	31 267	846	37.0
Germany (2016)	20 936	5 952	3.5

Source: STECF database, except for Germany (German Federal Statistical Office)

Figure 18. Number of aquaculture production enterprises in selected EEA States, 2013



Source: Economic Report of EU aquaculture sector (STECF 16-19)
** Greece data is from 2014*

11.1.6. NUMBERS EMPLOYED IN AQUACULTURE IN SELECTED EU MEMBER STATES

Figure 19 shows the number of employees in aquaculture production in selected EU Member States in 2013, based on available data from the STECF database. Employment is split by gender and expressed in full-time equivalents (FTEs).

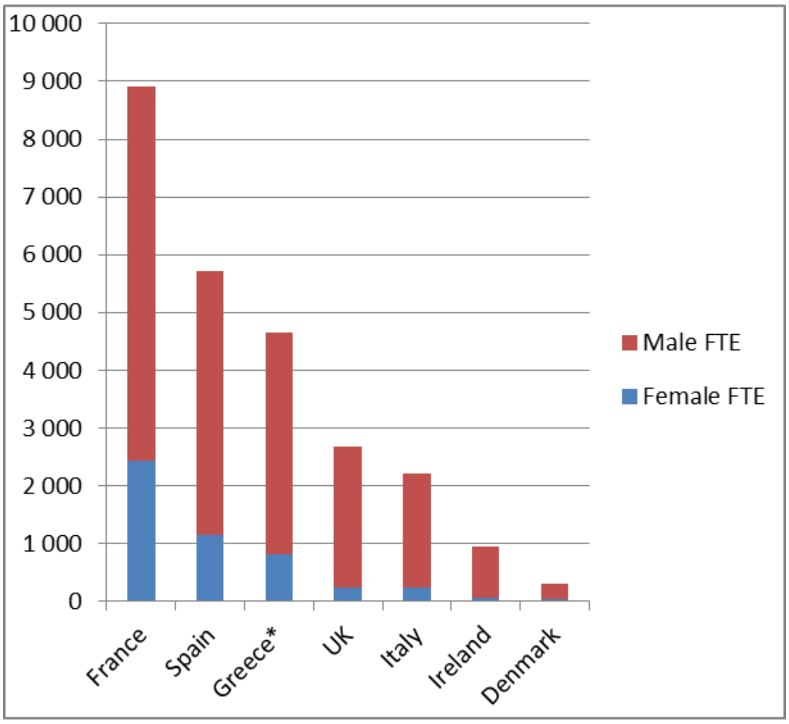
France and Spain have the greatest employment, which is consistent with the greater number of enterprises in these Member States (as shown in Figure 18). Greece has a relatively high level of employment, which is consistent with the high productivity of its enterprises.

Denmark has the lowest level of employment and the highest employment productivity. In terms of employment productivity, it is followed by the United Kingdom and Italy.

Total employment decreased between 2009 and 2013 in all EU Member States where data is available, except for the United Kingdom.

The share of female employment is greatest in France (28 %), Spain (21 %) and Greece (17 %). In the other EU Member States this percentage ranges from 7 - 10 %. The degree of full employment (FTE/employee) is nearly 90 % in the United Kingdom and Greece, in contrast to Spain where it is around 25 %. The level of full-time employment in the other EU Member States where data is available ranges from 40 - 60 %.

Figure 19. Full-time equivalent (FTE) employment in aquaculture production in selected EU Member States, 2013



Source: Economic Report of EU aquaculture sector (STECF 16-19)
** Greece data is from 2014*

11.2. ECONOMICS OF IMPROVING ANIMAL WELFARE PRACTICES

To gain insight into the economic consequences of improving welfare practices during transport, and during stunning and slaughter of the five species, the following analytical steps were performed:

- a qualitative description of the additional measures to be taken – in chapter 10 a detailed description is given of the different systems available to improve welfare of farmed fish;
- a summary was made based on the analysis of the requirements for the different species (chapter 10)
- insight into the present economic performance of an average fish farm in the different case countries is presented in chapter 11.1;
- collection of data related to additional investments, cost (e.g. depreciation and labour) and potential savings and/or additional revenues (see Table 41);
- calculation of the effects of implementing additional measures on cost price.

Table 41. Investment needs to comply with welfare practices in the different fish species

	Transport	Stunning		Killing
Species	Water quality equipment	Electro stunner	Percussion stunner	Decapitation robot
Atlantic Salmon	Common practice	+ [A]	+ [A]	+
Common Carp	Common practice	+		NA
European sea bass/ Gilthead sea bream	Common practice	+		NA
Rainbow trout	Common practice	+ (abattoir)		NA

[A] – either/or
NA – Not applicable

For each of the investigated species in the case countries, the additional investments and annual costs of adhering to improved animal welfare practices since 2009 are calculated for the average aquaculture farm for the species under study. These are described in the following paragraphs.

Additional cost related to improved welfare during transport

As the use of camera observation systems and water quality equipment was already widespread in 2009, farms do not need to make additional investments to meet welfare standards. Therefore, the compliance costs are disregarded in this study.

Additional cost related to improved welfare during stunning, killing and slaughter

In the calculations on additional costs related to improved welfare during stunning, killing and slaughter, it is assumed that every aquaculture farm needs to possess its own means of transportation and primary processing. Also, it is assumed that the average enterprise has not implemented welfare practices. Therefore, the total benefits and costs of adhering to the improved welfare practices are calculated for implementing all required measures. This is considered as the 'worst case scenario'.

Impact on competitiveness

To assess the impact on the competitiveness of aquaculture in the evaluated countries, the change in cost price per kg as compared to the sales price is shown.

11.2.1. COSTS OF EQUIPMENT TO IMPROVE ANIMAL WELFARE

In calculating the costs of improved welfare, it is assumed that every aquaculture farm possesses its own means of transportation and primary processing, which is the worst case scenario[48]. In case of co-operation between aquaculture farms or the use of specialised transporters and slaughterhouses, the volume of fish transported and slaughtered will increase and thus reduce the costs.

Table 42 provides an overview of the costs of equipment that can be used to improve the welfare of farmed fish during transport and slaughter. Data on investment costs, depreciation, maintenance and extra labour requirement were collected from equipment manufacturers. For extra labour, negative numbers in hours per tonne fish processed for trout and salmon are given, indicating cost saving due to gains in efficiency.

[48] Aquaculture farms that had already invested in new equipment for improved welfare before 2012 would have incorporated the costs into the economic figures for 2012. However – apart from salmon farms – this is not very likely to be common practice.

Table 42. Cost for additional equipment for transport and slaughter to improve welfare of farmed fish

Type of equipment	Investment (euros)	Depreciation rate	Maintenance rate	Costs per year (euros)	Extra labour (hours/tonne)
Transport:					
camera observation system	20 000	15.0%	5.0%	4 000	
water quality equipment	20 000	15.0%	5.0%	4 000	
Stunning:					
pump 40-50 ton/hr	200 000	10.0%	2.0%	24 000	
pump 20-30 ton/hr	100 000	10.0%	2.0%	12 000	
pump 2-3 ton/hr	50 000	10.0%	2.0%	6 000	
electro stunner in water on harvest boat 5 ton/hr (sea bass/sea bream)	140 000	10.0%	1.0%	15 400	
electro stunner in water in abattoir 20 ton/hr (salmon)	120 000	10.0%	1.0%	13 200	
electro stunner in water in abattoir 20 ton/hr (trout)	100 000	10.0%	1.0%	11 000	-1.500
electro stunner in water in abattoir 5-10 ton/hr (carp)	70 000	10.0%	1.0%	7 700	
electro stunner after dewatering 3-20 ton/hr (salmon, trout)	55 000	10.0%	5.0%	8 250	-0.075
electro stunner after dewatering 2-20 ton/hr (carp, sea bass/sea bream)	40 000	10.0%	5.0%	6 000	
percussion stunner 5-20 ton/hr (salmon,)	60 000	10.0%	5.0%	9 000	-0.075
dewater unit after stunning	5 000	10.0%	2.0%	600	
dewater and singulation unit before stunning	50 000	10.0%	2.0%	6 000	
Killing:					
decapitation robot	100 000	10.0%	10.0%	20 000	-0.200

Source: manufacturers of equipment

11.2.2. ATLANTIC SALMON

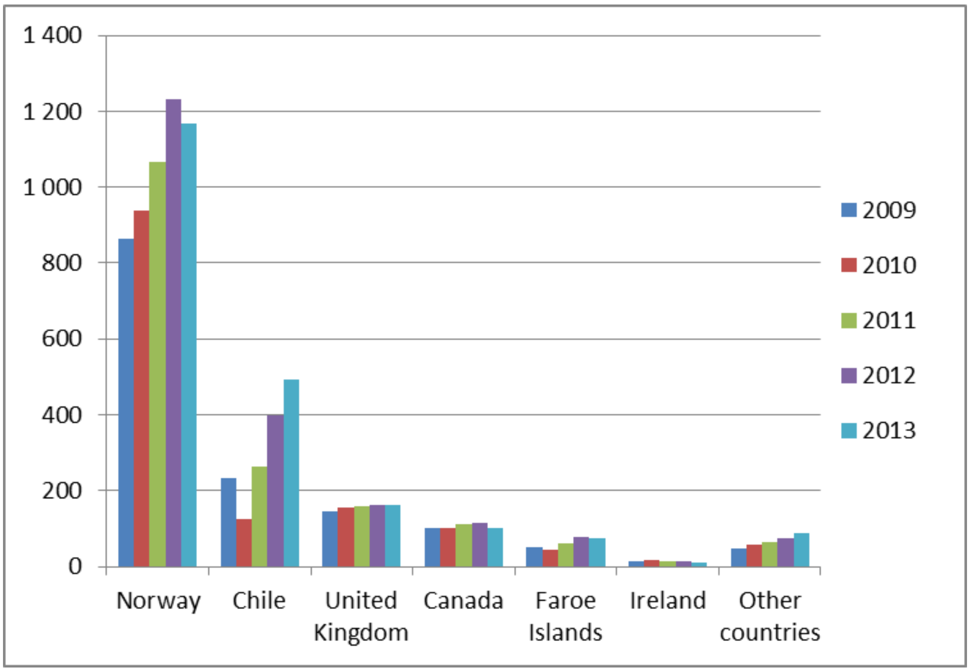
11.2.2.1. PRODUCTION OF ATLANTIC SALMON FROM AQUACULTURE

Figure 20 shows the production quantity of Atlantic salmon from aquaculture in major producing countries in the world in the period 2009-2013.

Norway is by far the largest producer with 56 % of world production, followed by Chile with 24 %. Although Norway has shown a respectable growth of 35 % in the period 2009-2013, Chile has more than doubled its production quantity with growth of 111 % over the last five years. The United Kingdom (market share 8 %), Canada (5 %) and the Faroe Islands (4 %) are the other countries in the top five producers, with growth rates of 13 %, zero and 48 % respectively over the last five year period.

Ireland has a share of just 0.4 % of world production, and Irish production has decreased from a peak in 2010.

Figure 20. Salmon production from aquaculture, 2009-2013 (1 000 tonnes live weight)



Source: FAO Global Fishery and Aquaculture Statistics version 2016.1.2

11.2.2.2. VALUE OF ATLANTIC SALMON PRODUCTION FROM AQUACULTURE

The prices for salmon produced have gone up in the last 5 years in all the top five countries. This is indicated by the fact that the value of production has increased more than the increase in production quantity: Norwegian production increased in quantity by 35 %, but in value by 100 % from 2009 to 2013. Similarly, production in Chile grew in quantity by 111 % and in value by 154 %. In the United Kingdom, Canada and Faroe Islands, the respective figures for production and value increase were 13 % and 64 %, 0 % and 17 %, and 48 % and 90 %.

Four of the top five countries realised growth in the value of production over 60 % in the period 2009-2013. The fifth, Canada delivered a more modest 17 % increase in production value over the five years.

11.2.2.3. SALMON EXPORTS

Table 43 shows the export quantities of Atlantic and Danube salmon as a fresh, chilled or frozen commodity from the major producing countries in the world during the period 2009-2013. Total exports (including re-export) are equal to about 55 % of world aquaculture production of salmon in 2009-2011, and up to 80 % in 2012-2013. However, the export data may also include wild catch.

Table 43. Export of fresh, chilled and frozen Atlantic and Danube salmon, 2009-2013 (1 000 tonnes)

Country	2009	2010	2011	2012	2013	Change 2009-2013	Share of total, 2013
Norway	612	665	734	879	841	37%	49.2%
Chile	78	43	64	91	136	73%	8.0%
United Kingdom*	50	61	70	70	89	77%	5.2%
Canada	68	71	67	83	64	-6%	3.7%
Faroe Islands	31	23	36	47	44	40%	2.5%
Ireland**	9	8	9	8	7	-14%	0.4%
Other countries	10	15	20	520	529	5 136%	30.9%
Total world	**858**	**885**	**1 000**	**1 699**	**1 709**	**99%**	**100.0%**

Source: FAO Global Fishery and Aquaculture Statistics version 2016.1.2
** UK data from Comtrade*
*** Ireland data from the Irish Sea Fisheries Board (BIM)*

Table 44 shows the export value of Atlantic and Danube salmon as a fresh, chilled or frozen commodity from the major producing countries in the period 2009-2013. Exports (including re-export) are equivalent to about 60 % of world aquaculture production by value in 2009-2011 and up to 85 % in 2012-2013. However, these figures may also include wild catch.

Table 44. Export value of fresh, chilled and frozen Atlantic and Danube salmon, 2009-2013 (USD million)

Country	2009	2010	2011	2012	2013	Change 2009-2013	Share of total, 2013
Norway	2 988	4 087	4 170	4 147	5 626	88%	49.4%
Chile	318	278	410	422	796	151%	7.0%
United Kingdom*	306	424	559	463	708	131%	6.2%
Canada	385	427	423	424	434	13%	3.8%
Faroe Islands	162	155	213	229	315	94%	2.8%
Ireland**	45	50	52	78	54	20%	0.5%
Other countries	52	73	81	2 465	3 459	6 564%	30.4%
Total world	**4 256**	**5 494**	**5 908**	**8 228**	**11 392**	**168%**	**100.0%**

Source: FAO Global Fishery and Aquaculture Statistics version 2016.1.2
** UK data from Comtrade*
*** Ireland data from the Irish Sea Fisheries Board (BIM). Export volumes and values are taken from BIM Annual Reports of 2012 and 2013, which present figures of 61 and 42 million euros respectively, equivalent to 78 and 54 million USD.*

Norway is by far the largest exporter of salmon with 49 % of world export – both in quantity and in value – and showed a 35 % growth in exports between 2009 and 2013. Sweden and Denmark imported in total around 0.5 million tonnes in both 2012 and 2013 and subsequently exported nearly 90 % of this quantity. This re-export explains the steep rise in total world exports in 2012 and 2013.

The shares of the other top five producers in world export are Chile, with a quantity of 8.0 % and a value of 7 %, the United Kingdom (quantity 5.6 % and value 6.5 %), Canada (3.7 % and 3.8 %) and the Faroe Islands (2.5 % and 2.8 %). Of these, the United Kingdom showed a ten-fold increase in exports between 2009 and 2013, due largely to re-export, Chile and the Faroe Islands showed growth figures in quantity of 70 % and 40 %, and Canada experienced stagnation in export quantity. Chile and the Faroe Islands showed growth in export value of 151 % and 94 %, and Canada showed 13 % growth in export value despite a fall in quantity. Figures from the Irish Sea Fisheries Board (BIM) indicate that export of Irish salmon is quite substantial. In the period 2010-1015 around 75% of the Irish production volume was exported at a price well above the average EU market price [49]. The import and re-export indicate that international supply chains exist for salmon production, where production and processing can be done in different countries.

Table 45. Structure and finances of average salmon farms (1 000 euros)

Data per enterprise	Norway		United Kingdom		Ireland	
	2009	2012	2009	2012	2009	2012
Structure						
Number of enterprises	106	94	NA	62	17	19
Production						
Total sales volume (tonnes)	6 359	8 997	NA	2 679	723	655
Employment						
Total employees	15.1	21.7	NA	23.2	9.7	10.3
Total FTE	15.1	21.7	NA	21.1	8.2	9.0
Capital Value						
Total value of assets	10 715	18 784	NA	7 804	4 030	4 748
Income						
Turnover	18 250	27 619	NA	11 234	3 845	3 984
Subsidies and other income	988	1 801	NA	20	0	58
Operating Costs						
Wages and salaries	1 013	1 910	NA	501	789	1 148
Feed costs	7 755	13 397	NA	3 602	1 603	1 100
Livestock costs	1 528	2 669	NA	100	0	342
Other operational costs	3 413	6 132	NA	3 963	1 384	1 522
Capital Costs						
Depreciation and financial costs	1 084	1 669	NA	395	10	99
Net farm income						
Income minus operating and capital costs	4 446	3 644	NA	2 692	59	-169

Source: Scientific, Technical and Economic Committee for Fisheries (STECF) - Economic Report of EU aquaculture sector (STECF 14-18) & Fiskeridirektoratet Norge (2013)

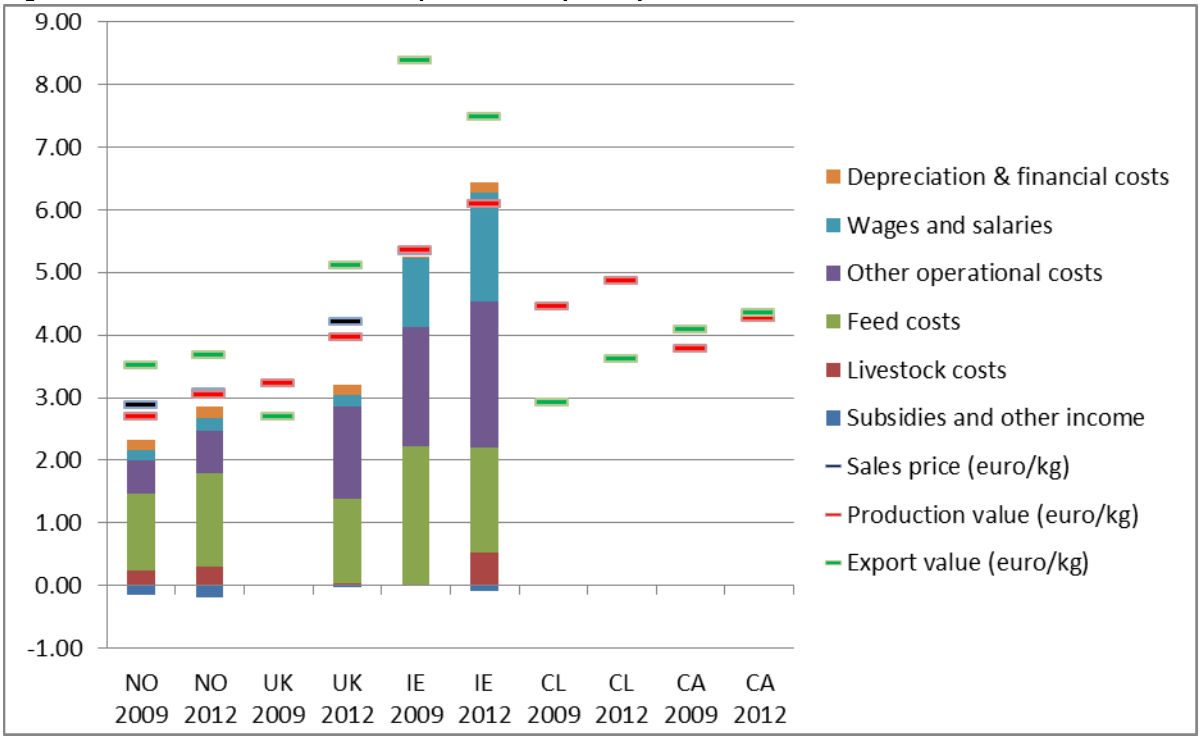
Figure 21 shows that the cost price of Atlantic salmon in Norway (NO) in 2012 amounts to 2.66 euros/kg, in the United Kingdom (UK) to 3.19 euros/kg and in Ireland (IE) to 6.34 euros/kg. Sales price in Norway and the United Kingdom is sufficient to cover all the costs, but in Ireland the costs exceed the sales price.

For comparison, the production value (= sales price) and export value per kg from FAO Statistics are presented. As one might expect, sales price from the STECF database and production value from the FAO statistics are almost the same and often overlap each other in the graph. Export value is expected to be higher, as the costs of slaughtering, packaging and transportation are included.

Therefore, it is remarkable that in Chile (CL) the export value is lower than the production value. It seems that the United Kingdom and probably Norway are more than able to compete with Chile and Canada (CA) on production value.

[49] Data received from Irish Sea Fisheries Board (BIM dd 28/09/2017)

Figure 21. Cost of Atlantic salmon production (euros)



Sources:

- Scientific, Technical and Economic Committee for Fisheries (STECF) - Economic Report of EU aquaculture sector (STECF 14-18)
- Fiskeridirektoratet Norge (2013)
- Production and export values are calculated form FAO Global Fishery and Aquaculture Statistics version 2016.1.2

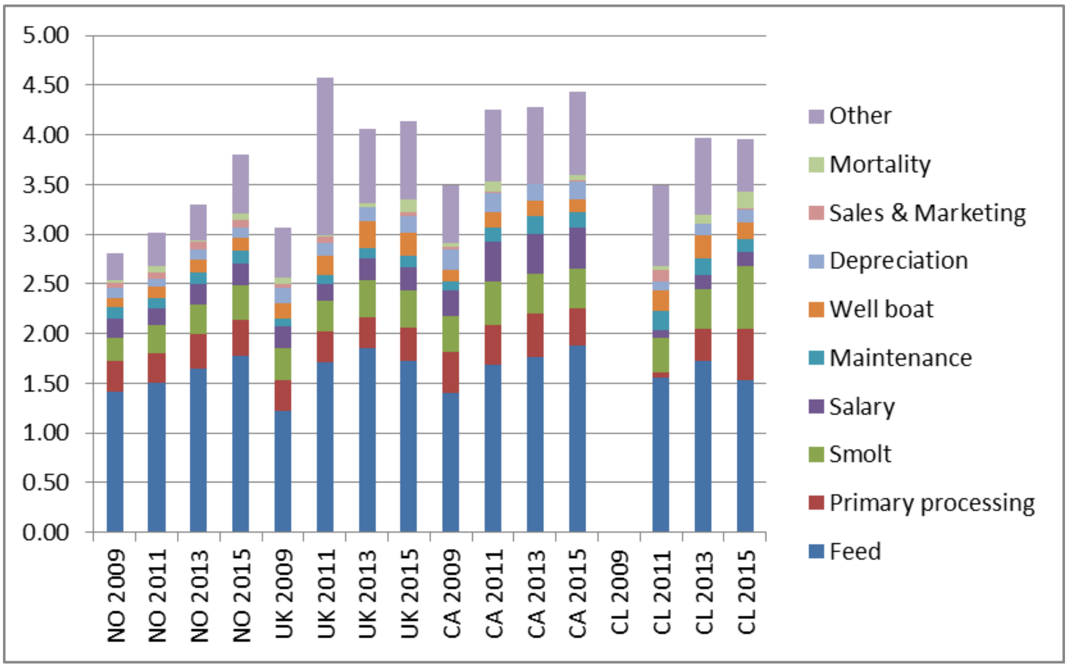
NO= Norway, UK= United Kingdom, IE = Ireland , CA=Canada, CL= Chile

Figure 22 shows that the cost price of Atlantic salmon (head on gutted – HOG) has increased in all countries between 2009 and 2015. Norway has realised the lowest cost price of 3.20 euros/kg on average, whereas the cost price in Chile is around 13% higher and in United Kingdom and Canada around 28% higher (source Marine Harvest[50]).

The costs of transporting live fish by well-boats make up around 4 %, and the costs of primary processing (slaughtering, gutting and packing on ice) around 10 % of the total cost price in all four countries. In 2015, transportation costs ranged between 0.15 and 0.23 euros/kg HOG and the costs of primary processing between 0.33 and 0.52 euros/kg HOG. These costs are heavily dependent on quantity, logistics and level of automation.

[50] Marine Harvest is world leader in farmed Atlantic salmon and is active in all major production regions in the world: Norway, the United Kingdom, Canada and Chile. Every year Marine Harvest publishes the "Salmon Farming Industry Handbook" to give investors and financial analysts a better insight into the salmon farming industry. In these handbooks, the company also presents cost prices of salmon gutted on ice in a box for all production regions, illustrating the main cost components including transportation and primary processing. However as is clearly stated in the handbooks, the cost level is only chosen for illustration purposes.

Figure 22. Cost price of Atlantic salmon (head on gutted) in the main producing countries (euros/kg)



Source: Marine Harvest, Salmon Farming Industry Handbook 2010, 2012, 2014 and 2016

11.2.2.4. Improved welfare

For Atlantic salmon, two alternative methods to improve fish welfare are considered: electrical stunning before dewatering and percussive stunning after dewatering, both followed by decapitation by robot. Table 46 shows that, in the worst case scenario total required additional investments range between 410 000 and 425 000 euros per slaughter facility. The annual costs of the extra investments are partly compensated by the saving of labour, and in the case of large volume producers – as in Norway – the labour saving results in an overall reduction in the cost per kg of fish. Overall, in the three countries there is hardly any effect on cost price (less than 1.5%).

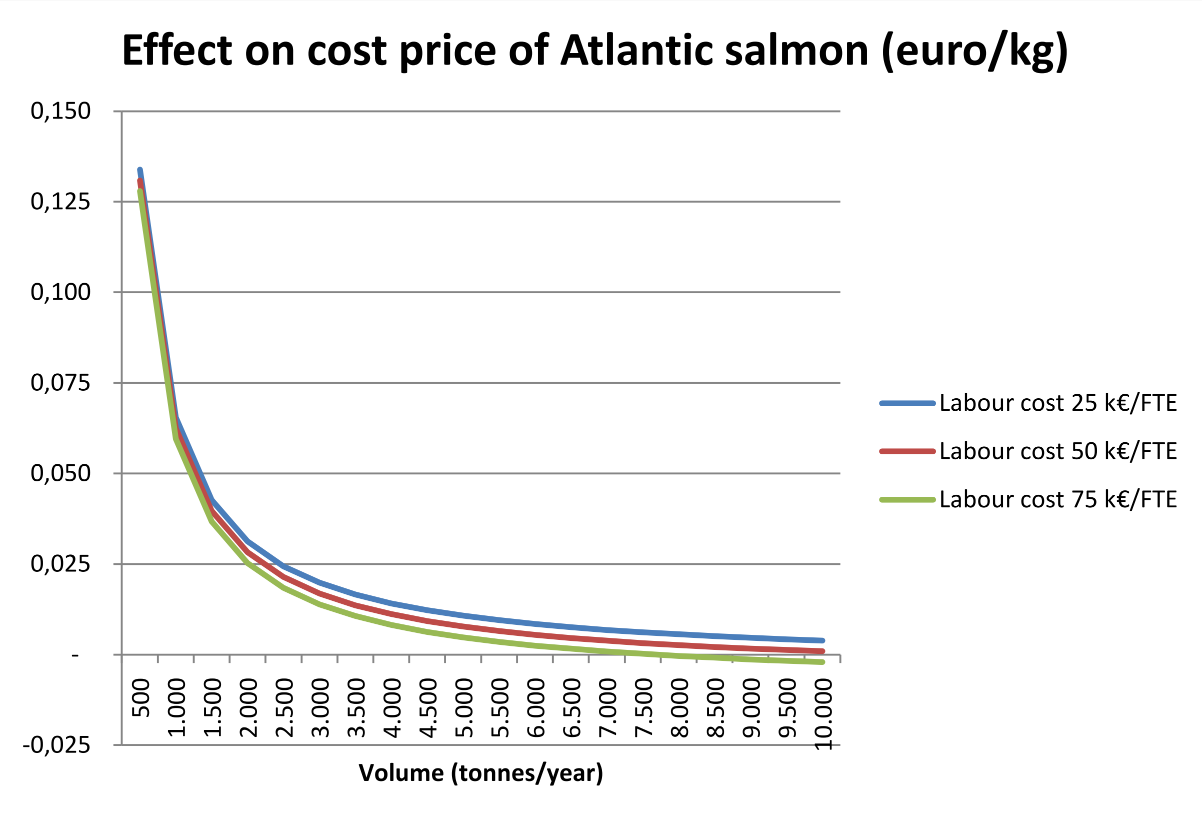
Previous analysis has shown that sales volume and labour costs per employee strongly influence the effect on cost price. Therefore, the effects of salary variation when achieving improved welfare practices is investigated.

In Figure 23, the results of a sensitivity analysis are presented, which shows that at salary levels around a volume of 1 250 tonnes, the effect on cost price drops below 5 euro cents/kg of fish. It also shows that for volumes over 7 500 tonnes per year and higher salaries, the implementation of welfare practices even results in cost savings compared to the basic situation: the savings in labour costs outweigh the additional investments.

Table 46. Cost of adhering to improved animal welfare practices – Atlantic salmon (euros)

Per enterprise	Electrical stunning before dewatering			Percussion stunning after dewatering		
	Norway	United Kingdom	Ireland	Norway	United Kingdom	Ireland
	2012	2012	2012	2012	2012	2012
Total sales volume (tonnes)	8 997	2 679	655	8 997	2 679	655
Sales price (euros per kg)	3.07	4.19	6.09	3.07	4.19	6.09
Transport:						
water quality equipment	common practice			common practice		
Stunning:						
pump 40-50 ton/hr	200 000	200 000	200 000	200 000	200 000	200 000
electro stunner in water in abattoir 20 ton/hr	120 000	120 000	120 000			
percussion stunner 5-20 ton/hr				60 000	60 000	60 000
dewater unit after stunning	5 000	5 000	5 000			
dewater and singulation unit before stunning				50 000	50 000	50 000
Killing:						
Decapitation robot	100 000	100 000	100 000	100 000	100 000	100 000
Total extra investments since 2009 (euros)	425 000	425 000	425 000	410 000	410 000	410 000
Extra annual costs (euros)						
- depreciation and maintenance	57 800	57 800	57 800	59 000	59 000	59 000
- interest costs on investments (5%)	10 625	10 625	10 625	10 250	10 250	10 250
- labour costs	-94 281	-7 562	-9 948	-129 636	-10 398	-13 678
Total extra annual costs (euros)	-25 856	60 863	58 477	-60 386	58 852	55 572
Effect on cost price (euros per kg)	-0.00	0.02	0.09	-0.01	0.02	0.08
as % of sales price	-0.09%	0.54%	1.47%	-0.22%	0.52%	1.39%

Figure 23. Sensitivity analysis of sales volume and labour costs on the cost price of Atlantic salmon when adhering to improved animal welfare practices (euros/kg)



11.2.3. Common carp

11.2.3.1. Production of common carp

Table 47 shows common carp production from aquaculture in the major producing countries in the period 2009-2013. China is the dominant producer with 76 % of world production in 2013. China's share in the production value of common carp from aquaculture in the period 2009-2013 was 63 % by value is less than its 76 % share by quantity. The EEA States (Poland, Czech Republic, Hungary and Germany) produced together just 1.3 %.

World carp production grew by 26 %, between 2009 and 2013, whilst the combined production of the four EEA States declined by 8 %. Only Poland showed a small increase in production of 3 %.

World production value grew by 35 % overall, with China production growing at 25 %. Other countries (not identified individually in the table) contributed markedly to the overall increase in the value of production. As with production volume, three of the four EEA States experienced a decline in production value between 2009 and 2013. Germany's production value declined by 36 %, Hungary's by 14 % and the Czech Republic's by 8 %. Only Poland showed growth, of 3 %.

Table 47. Common carp production from aquaculture, 2009-2013 (1 000 tonnes live weight)

Country	2009	2010	2011	2012	2013	Change 2009-2013	Share of total, 2013
China	2 462	2 538	2 718	2 897	3 022	23 %	76.1 %
Russian Federation	52	57	56	61	56	8 %	1.4 %
Ukraine	20	20	20	20	20	-2 %	0.5 %
Poland	18	15	14	18	19	3 %	0.5 %
Czech Republic	17	18	18	18	17	-3 %	0.4 %
Belarus	14	13	13	12	10	-25 %	0.3 %
Hungary	10	10	11	10	10	-3 %	0.2 %
Germany	10	10	5	6	6	-42 %	0.1 %
Other countries	543	740	642	713	811	49 %	20.4 %
Total world	**3 146**	**3 421**	**3 498**	**3 754**	**3 970**	**26 %**	**100.0 %**

Source: FAO Global Fishery and Aquaculture Statistics version 2016.1.2

11.2.3.2. Common carp exports

Table 48 shows the quantity of carp exported as a live, fresh, chilled or frozen commodity from the major producing and exporting countries in the period 2009-2013.

Export (including re-export) accounts for only a very small part of world carp production: around 0.5 % in 2009-2011 and approximately 2.0 % in 2012-2013. Most carp from aquaculture is therefore processed and consumed in the country of origin.

China is the largest exporter with a 60 % share in 2013, having shown steep growth from 2012 onwards. The Czech Republic lost its second rank to Turkey, both with a share of about 10 %. Turkey realised a steep growth from 2011 onwards, whereas the Czech Republic maintained a steady growth of 7 % over the period 2009-2013.

Table 48. Export of live, fresh, chilled and frozen carp, 2009-2013 (1 000 tonnes)

Country	2009	2010	2011	2012	2013	Change 2009-2013	Share of total, 2013
China	3.21	2.40	2.30	41.37	48.50	1 412 %	59.0 %
Czech Republic	7.52	7.98	8.29	8.13	8.02	7 %	9.8 %
Turkey	0.20	0.18	5.13	7.75	8.91	4 356 %	10.8 %
Hungary	0.34	0.78	1.25	0.89	1.39	306 %	1.7 %
Poland	0.12	0.12	0.09	0.55	0.57	380 %	0.7 %
Germany	0.03	0.03	0.05	0.04	0.05	58 %	0.1 %
Others	2.30	3.37	4.94	14.94	14.69	538 %	17.9 %
Total world	**13.7**	**14.8**	**22.1**	**73.7**	**82.2**	**499 %**	100.0 %
% of world production	0.4 %	0.4 %	0.6 %	2.0 %	2.1 %		

Source: FAO Global Fishery and Aquaculture Statistics version 2016.1.2

Table 49 shows the export value of common carp in the period 2009-2013. The figures are consistent with those on quantity, showing the emergence of China as the dominant exporter since 2012. Whereas Turkey overtook the Czech Republic in 2013 as the second exporter by quantity, the Czech Republic achieves a much higher value for its exports and retains second place by value.

Table 49. Export value of live, fresh, chilled and frozen common carp, 2009-2013 (USD million)

Country	2009	2010	2011	2012	2013	Change 2009-2013	Share of total, 2013
China	6.9	5.2	5.4	128.7	155.4	2 156 %	71.3 %
Czech Republic	19.9	22.4	27.9	24.6	25.9	30 %	11.9 %
Turkey	0.1	0.1	3.5	5.5	6.6	4 400 %	3.0 %
Hungary	1.1	2.1	3.6	2.3	3.4	208 %	1.5 %
Poland	0.4	0.5	0.4	1.1	1.4	222 %	0.6 %
Germany	0.1	0.1	0.2	0.2	0.2	43 %	0.1 %
Others	7.8	12.0	13.9	28.0	25.2	225 %	11.6 %
Total world	**36.3**	**42.5**	**54.9**	**190.4**	**217.9**	**500 %**	**100.0 %**
% of world production	0.9 %	0.9 %	1.1 %	3.7 %	4.0 %		

Source: FAO Global Fishery and Aquaculture Statistics version 2016.1.2

11.2.3.3. Structure and finances of average carp farms

Table 50 shows the structure and finances of sample carp farms in Poland, Germany and Romania in 2009 and 2012. The STECF 14-18 database lacks data on carp production in the selected countries – Czech Republic, Poland and Germany. Therefore, other data sources for a sample of farms in Poland and a modelled farm in Germany are used, as well as data for Romania instead of the Czech Republic.

In 2012, the average enterprise in the Polish sample produced six to nine times as much sales volume as the model farm in Germany and the average enterprise in Romania. The number of employees was broadly similar in all three country samples. Despite subsidies and other income (e.g. from recreational fishing) the net farm income is negative, apart from Romania in 2012.

Table 50. Structure and finances of average carp farms (1 000 euros)

Data per enterprise	Poland*		Germany**		Romania*	
	2009	2012	2009	2012	2009	2012
Structure						
Number of enterprises	18	4		1	94	94
Production						
Total sales volume (tonnes)	282	384		43	46	61
Employment						
Total employees	0.0	10.3		4.6	14.3	13.3
Total FTE	0.0	10.3		4.6	13.7	11.6
Capital Value						
Total value of assets	0	0		0	691	365
Income						
Turnover	553	867		103	85	101
Subsidies and other income	31	34		67	71	45
Operating Costs						
Wages and salaries	225	161		62	52	27
Feed costs	94	387		14	30	33
Livestock costs	28	3		1	17	32
Other operational costs	223	315		106	96	14
Capital Costs						
Depreciation and financial costs	48	115		28	18	18
Net farm income						
Income minus operating and capital costs	-34	-80		-42	-58	22

Sources:
** Scientific, Technical and Economic Committee for Fisheries (STECF) - Economic Report of EU aquaculture sector (STECF 14-18), Turkovski and Lirski (2013) on Poland,*
*** Landesfishereiverband Brandenburg - for German modelled farm*

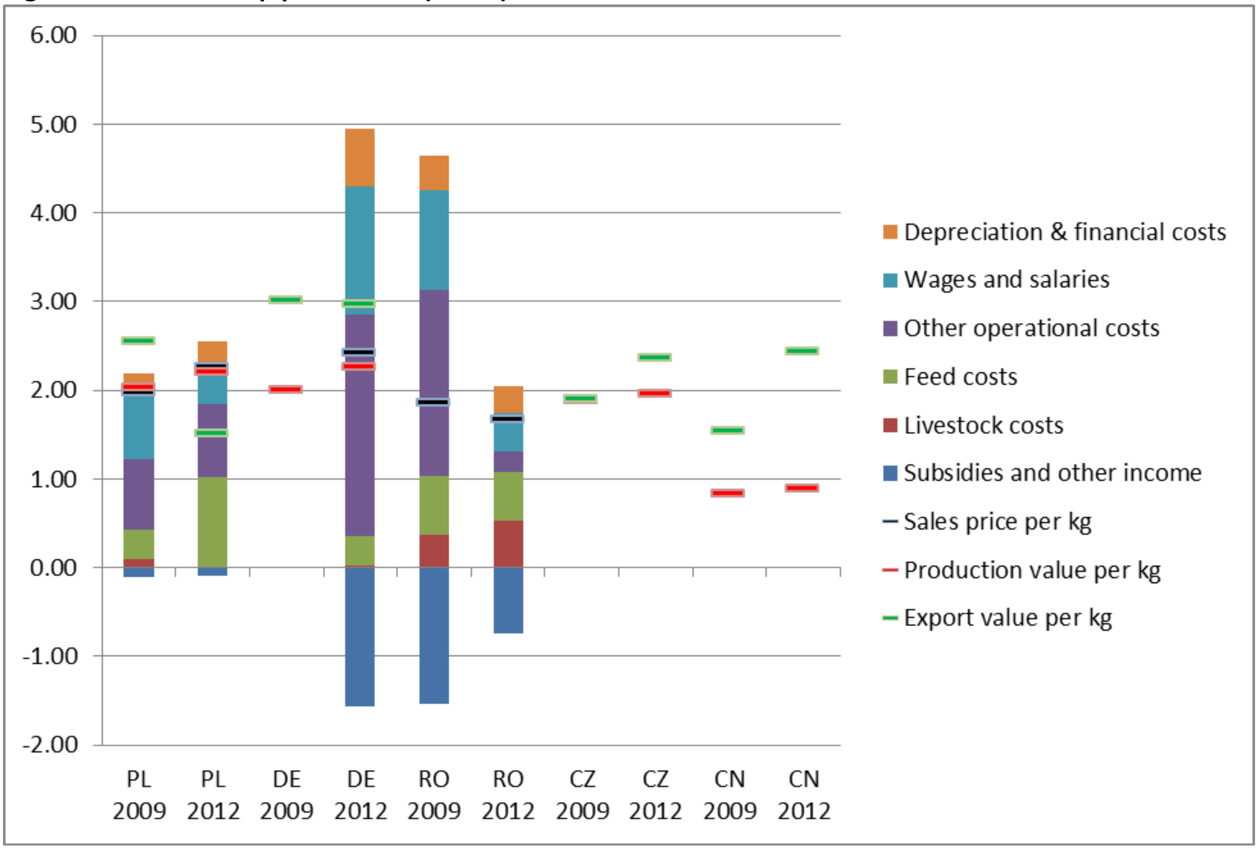
Figure 24 shows the cost price (minus subsidies and other income) of common carp in 2012 was 2.08 euros/kg in Poland (PL), 3.38 euros/kg in Germany (DE), and 1.31 euros/kg in Romania (RO). In all cases, sales prices were not sufficient to cover costs, so subsidies and other income are needed to survive.

For comparison, the production value (= sales price) and export value/kg from FAO Statistics are also presented in Figure 24.

The comparison shows that, in Poland the export value in 2012 is lower than the production value. Higher prices are achieved in the domestic market compared to export.

Overall, it seems that production value in Europe varies around 2.00 euros/kg, which is more than twice the production value in China (CN). Also the export value in Europe is approximately 2.50 euros/kg higher than that of China.

Figure 24. Cost of carp production (euros)



Sources:

- Scientific, Technical and Economic Committee for Fisheries (STECF) - Economic Report of EU aquaculture sector (STECF 14-18)
- Turkovski and Lirski (2013) on Poland
- Landesfishereiverband Brandenburg on Germany
- Production and export values are calculated from FAO Global Fishery and Aquaculture Statistics version 2016.1.2

11.2.3.4. IMPROVED WELFARE

For common carp two alternative methods to improve fish welfare during slaughter are considered: electrical stunning before dewatering and electrical stunning after dewatering, both followed by manual gill cutting. Table 51 shows that, in the worst case scenario, total required additional investments range between 175 000 and 190 000 euros per slaughter facility. There is no saving of labour and the annual costs of the extra investments vary from 25 000 to 29 000 euros. In case of relatively large volume producers – as in Poland – the effect on cost price per kg of fish is quite limited at about 3.0 %.

For the small scale farms in Germany and Romania, the effect on cost price is notably high with an extra cost of 0.40 to 0.65 euros/kg of fish, as compared to the sales price increase of around 25 %. Low or even negative income on the majority of these farms will probably prevent producers in carp farming from investing if these additional costs are not compensated by higher revenues.

A large share of the carp farms in Poland, Romania and Germany have production volumes smaller than the volumes used in these calculations. For typical farms in Poland, Romania and Germany with sales volumes under 25 tonnes per year, the increase in sales price will be around one euro per kg. This is an increase in cost price of 40 %. Given the smaller average volumes per farm, less costly equipment for electrical stunning with a smaller hourly throughput could result in smaller investment needs and a smaller increase in cost price.

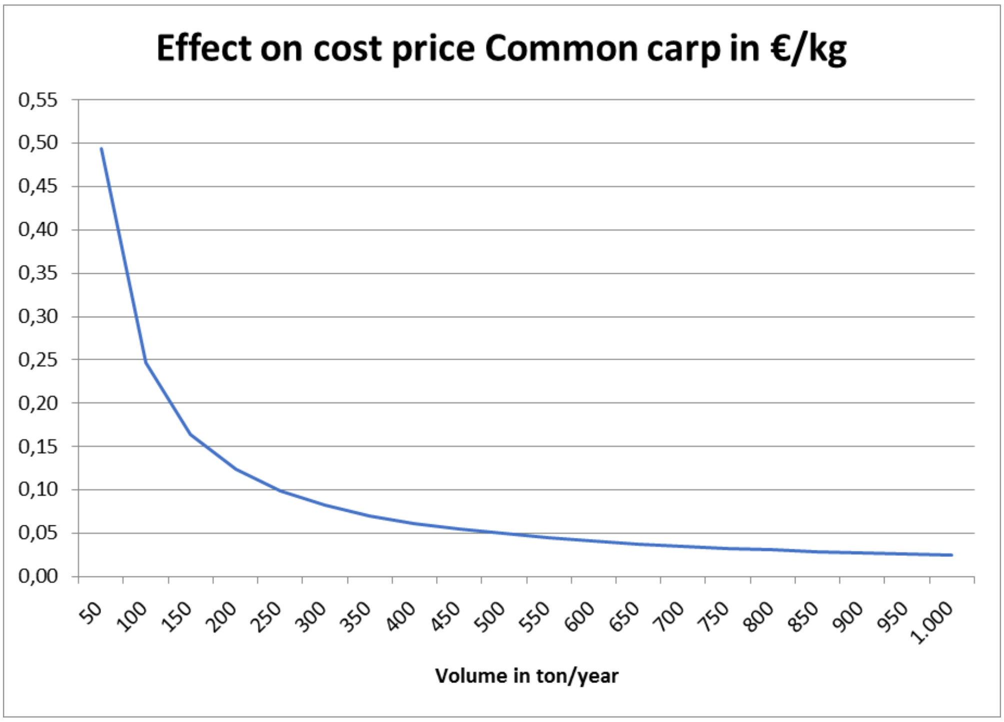
It is clear that sales volume influences the effect on cost price of adhering to improved welfare practices. In Figure 25 the results of a sensitivity analysis are presented, which shows that at a volume of around 500 tonnes, the effect on cost price is less than 5 euro cents/kg of fish.

In Germany, average carp farms are small. Their average annual production of 2.6 tonnes per farm is substantially less than the 43 tonnes of the model farm. However in Germany carp are mostly slaughtered in specialised abattoirs, which process the fish from several farms. The additional costs per kg of fish will decrease compared to the situation in which each farm has its own slaughter facilities. If the sales volume of multiple farms is combined, the effect on cost price will be similar to that in Poland.

Table 51. Cost of adhering to improved animal welfare practices – common carp (euros)

Per enterprise	Electrical stunning before dewatering			Electrical stunning after dewatering		
	Poland	Germany	Romania	Poland	Germany	Romania
	2012	2012	2012	2012	2012	2012
Total sales volume (tonnes)	384	43	61	384	43	61
Sales price (euros per kg)	2.26	2.41	1.66	2.26	2.41	1.66
Transport:						
water quality equipment	common practice			common practice		
Stunning:						
pump 20-30 ton/hr	100 000	100 000	100 000	100 000	100 000	100 000
electro stunner in water in abattoir 5-10 ton/hr (carp)	70 000	70 000	70 000			
electro stunner after dewatering 2-20 ton/hr (carp)				40 000	40 000	40 000
dewater unit after stunning	5 000	5 000	5 000			
dewater and singulation unit before stunning				50 000	50 000	50 000
Killing:						
Decapitation robot	not applicable			not applicable		
Total extra investments (euros)	175 000	175 000	175 000	190 000	190 000	190 000
Extra annual costs (euros)						
- depreciation and maintenance	20 300	20 300	20 300	24 000	24 000	24 000
- interest costs on investments (5%)	4 375	4 375	4 375	4 750	4 750	4 750
- labour costs	-	-	-	-	-	-
Total extra annual costs (euros)	24 675	24 675	24 675	28 750	28 750	28 750
Effect on cost price (euros per kg)	0.06	0.58	0.41	0.07	0.67	0.47
as % of sales price	2.85%	24.03%	24.41%	3.32%	28.00%	28.45%

Figure 25. Sensitivity analysis of sales volume on the cost price of common carp when adhering to improved animal welfare practices (euros/kg)



11.2.4. Rainbow trout

11.2.4.1. Production of rainbow trout

Table 52 shows the production of rainbow trout from aquaculture in major producing countries for 2009-2013.

The largest global producer is Chile with a 17 % share of world production – double its nearest competitor, Norway with 9 %. Italy (4.2 %), Denmark (4.1 %) and France (3.8 %) make up the top five producers, which together account for 40 % of world production. Chile's production fell markedly in 2013, and this fall continued in 2014, although not shown in the table.

Production decreased over the period in Chile, Norway, Italy and France; whereas it increased in Denmark, China, the Russian Federation and other unspecified countries. The top five producers by quantity are also the top five by value, although Chile's and Norway's shares of production value are greater than their shares of production quantity.

Norway's production value increased greatly in 2013 despite a fall in production quantity. Production value in Denmark increased sharply in 2013, as did France's in 2012. These figures show substantial fluctuations in production value between countries and also between years.

Table 52. Rainbow trout production from aquaculture, 2009-2013 (1 000 tonnes live weight)

	2009	2010	2011	2012	2013	Change 2009-2013	Share of total, 2013
Chile	215	220	224	254	143	-34 %	17.4 %
Norway	74	55	58	75	71	-3 %	8.7 %
Italy	36	33	34	34	34	-4 %	4.2 %
Denmark	29	33	33	31	34	15 %	4.1 %
France	33	32	29	30	31	-6 %	3.8 %
China	16	16	20	26	29	77 %	3.5 %
Russian Federation	17	19	21	22	24	40 %	3.0 %
Poland	15	13	11	11	12	-22 %	1.4 %
Other countries	317	329	360	399	440	39 %	53.8 %
Total world	**752**	**750**	**791**	**882**	**818**	**9 %**	**100.0 %**

Source: FAO Global Fishery and Aquaculture Statistics version 2016.1.2

11.2.4.2. Export of trout and char

Table 53 shows the export of trout and char as live, fresh, chilled or frozen commodities in major producing and exporting countries in the period 2009-2013. In total, this export trade (including re-export) is equivalent to about 25 % of world production.

The top producing country – Chile – is also the top exporter with a 31 % share of world exports in 2013. Chile is followed by six EEA States making up the top seven exporters: Norway (26 % share), Denmark (8.5 %), Italy (3.7 %), Sweden (3.7 %), Spain (3.3 %) and France (2.7 %). Sweden and Spain are among the top seven exporters, but are not among the top seven producers.

China and the Russian Federation are not major exporters.

Table 53. Export of live, fresh, chilled and frozen trout and char 2009-2013 (1 000 tonnes)

	2009	2010	2011	2012	2013	Change 2009-2013	Share of total, 2013
Chile	60	75	76	85	65	8 %	31.3 %
Norway	59	39	38	54	53	-9 %	25.6 %
Denmark	17	15	16	22	18	5 %	8.5 %
Italy	6	7	8	8	8	40 %	3.7 %
Sweden	7	7	7	8	8	15 %	3.7 %
Spain	5	6	4	7	7	27 %	3.3 %
France	5	5	4	5	6	27 %	2.7 %
Poland	1	1	1	1	1	75 %	0.6 %
Others	32	29	30	37	43	33 %	20.4 %
Total world	**191**	**183**	**185**	**226**	**209**	**9 %**	**100.0 %**

Source: FAO Global Fishery and Aquaculture Statistics version 2016.1.2

Table 54 shows the export value of trout and char in the period 2009-2013. The figures for export value show a similar picture to those for export quantity, although the unit value (price/tonne) of exports fluctuates between countries and between years.

Table 54. Export value of live, fresh, chilled and frozen trout and char 2009-2013 (USD million)

	2009	2010	2011	2012	2013	Change 2009-2013	Share of total, 2013
Chile	271	419	487	393	328	21 %	28.9 %
Norway	294	260	244	279	371	26 %	32.6 %
Denmark	76	72	87	97	88	16 %	7.8 %
Italy	20	24	32	30	33	66 %	2.9 %
Sweden	26	31	34	35	40	51 %	3.5 %
Spain	23	27	24	25	29	26 %	2.5 %
France	23	21	21	21	27	21 %	2.4 %
Poland	3	4	7	4	7	139 %	0.6 %
Others	150	142	172	188	215	44 %	18.9 %
Total world	**885**	**1 000**	**1 108**	**1 073**	**1 137**	**28 %**	**100.0 %**

Source: FAO Global Fishery and Aquaculture Statistics version 2016.1.2

11.2.4.3. Structure and finances of average trout farms

Table 55 presents the structure and finances of average trout farms in Denmark and Italy in 2009 and 2012, and in France in 2010 and 2012. The year 2010 is used for France because the STECF 14-18 database is lacking detailed data for France in 2009.

On average, Italy has the largest trout farms in terms of sales volume, assets, turnover and net income. However, the number of full-time equivalent (FTE) employees per farm is lower in Italy than in Denmark and France, although the number of employees is higher (suggesting part time labour during peak times).

Trout farms in Denmark and France have substantiality lower net incomes than Italy; and Denmark compares unfavourably with France despite having greater sales volume and turnover.

Table 55. Structure and finances of average trout farms (1 000 euros)

Data per enterprise	Denmark		France		Italy	
	2009	2012	2010	2012	2009	2012
Structure						
Number of enterprises	126	103	340	308	226	173
Production						
Total sales volume (tonnes)	248	271	119	108	491	338
Employment						
Total employees	2.5	2.6	3.8	3.9	5.0	3.6
Total FTE	1.7	1.9	3.0	3.1	0.0	0.7
Capital Value						
Total value of assets	1 008	1 071	321	287	2 197	1 553
Income						
Turnover	628	789	360	344	1 258	974
Subsidies and other income	27	47	8	62	19	34
Operating Costs						
Wages and salaries	132	144	74	74	168	116
Feed costs	232	295	151	184	485	283
Livestock costs	120	134	31	21	205	71
Other operational costs	143	188	76	89	159	156
Capital Costs						
Depreciation and financial costs	82	69	19	30	71	51
Net farm income						
Income minus operating and capital costs	-54	5	18	9	190	331

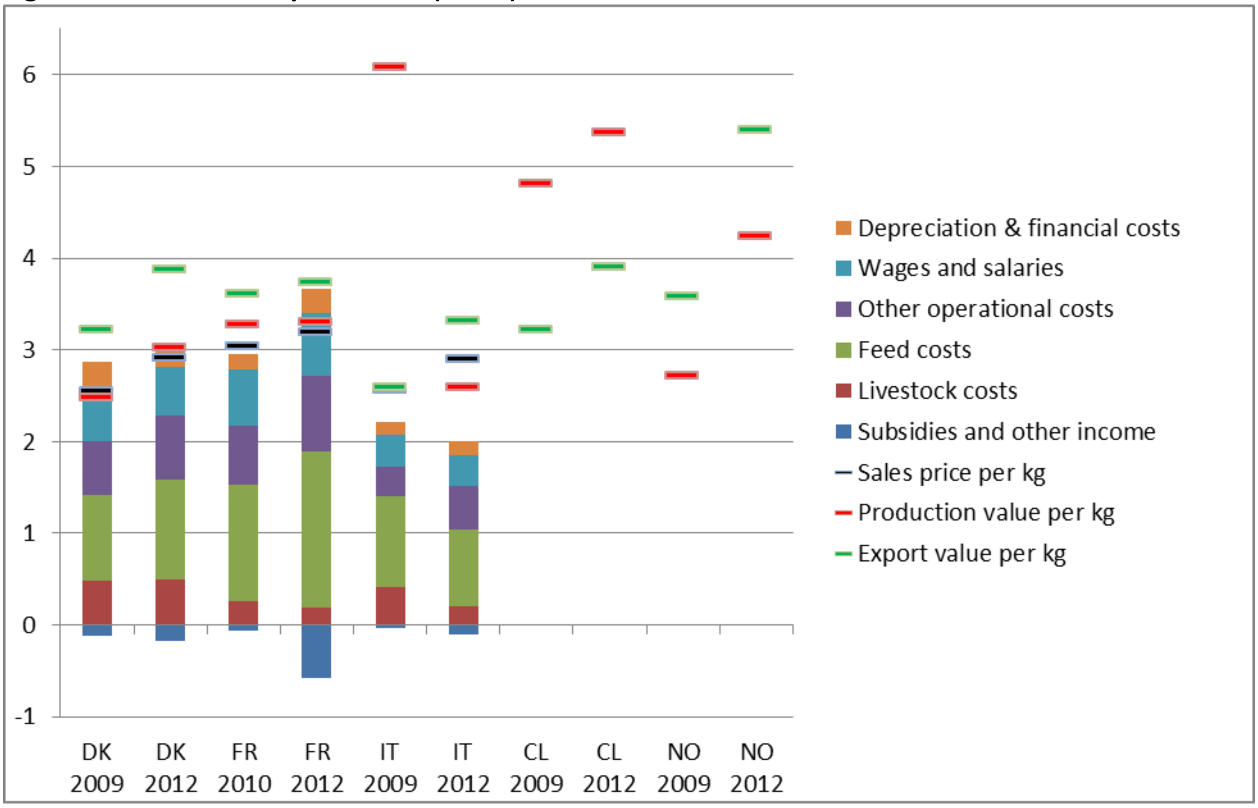
Source: Scientific, Technical and Economic Committee for Fisheries (STECF) - Economic Report of EU aquaculture sector (STECF 14-18)

Figure 26 shows that the cost price (minus subsidies and other income) of trout in Denmark (DK) in 2012 amounts to 2.89 euros/kg, in France (FR) to 3.10 euros/kg and in Italy (IT) to 1.90 euros/kg. Sales price in Italy is more than sufficient to cover all costs, but in Denmark and France this is hardly the case and subsidies and other income are needed to break even.

For comparison, the production value (= sales price) and export value per kg from FAO Statistics are presented in the figure.

In Chile (CL), the export value is much lower than the production value. It seems therefore that the European countries – and particularly Italy – are more than able to compete with Chile on production value.

Figure 26. Cost of trout production (euros)



Source: Scientific, Technical and Economic Committee for Fisheries (STECF) - Economic Report of EU aquaculture sector (STECF-14-18); production and export values are calculated from FAO Global Fishery and Aquaculture Statistics, version 2016.1.2

11.2.4.4. Improved welfare practice

For portion sized rainbow trout, the method to improve fish welfare is electrical stunning before dewatering, followed by manual gill cutting. Table 56 shows that, in the worst case scenario, the required additional investments are approximately 205 000 euros. The annual costs of the extra investments are partly compensated by the saving of labour, and in the case of relatively large volume producers and high salary levels – as in Italy – the labour saving can even result in an overall reduction in the cost per kg of fish.

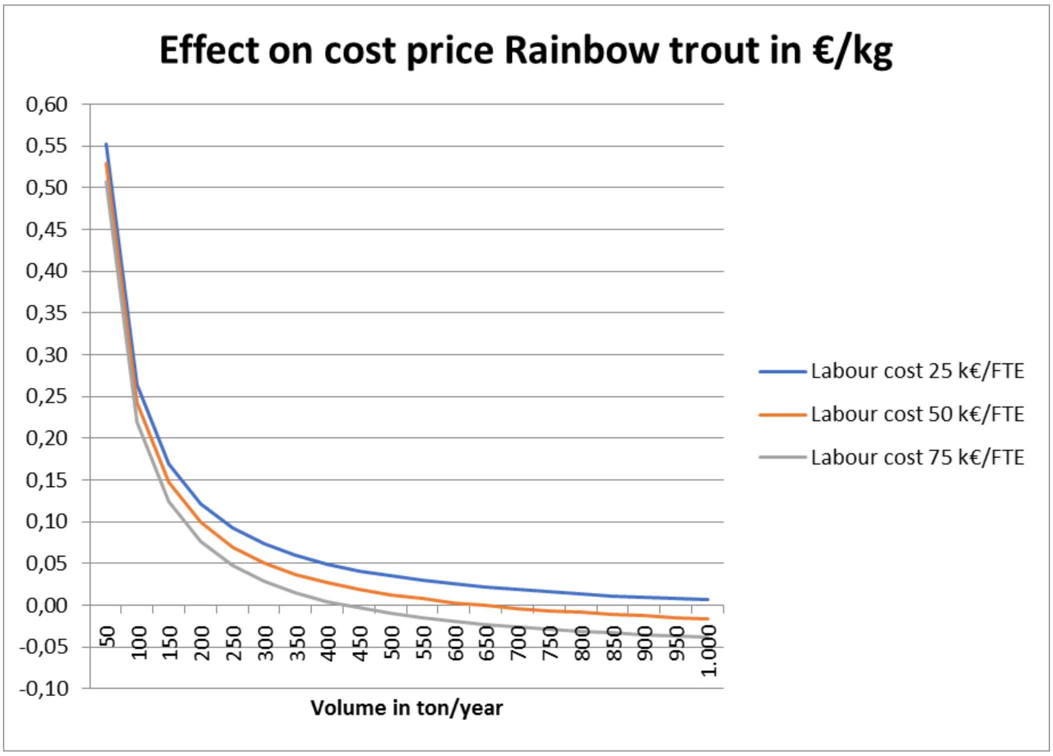
In the case of relatively large volume producers – as in Italy, Denmark and Poland – the effect on cost price is quite limited (less than 3.0 %). For the small-scale farms in France, the effect on cost price is notably high with an extra cost of 0.25 to 0.30 euros/kg of fish, as compared to the sales price increase of around 8.5 %.

Table 56. Cost of adhering to improved animal welfare practices – rainbow trout (euros)

Per enterprise	Electrical stunning before dewatering		
	Denmark	**France**	**Italy**
	2012	**2012**	**2012**
Total sales volume (tonnes)	271	108	338
Sales price (euros per kg)	2.91	3.18	2.89
Transport:			
water quality equipment		common practice	
Stunning:			
pump 20-30 ton/hr	100 000	100 000	100 000
electro stunner in water in abattoir 20 ton/hr (trout)	100 000	100 000	100 000
percussion stunner 5-20 ton/hr (salmon, trout)			
dewater unit after stunning	5 000	5 000	5 000
dewater and singulation unit before stunning			
Killing:			
Decapitation robot		not applicable	
Total extra investments (euros)	205 000	205 000	205 000
Extra annual costs (euros)			
- depreciation and maintenance	23 600	23 600	23 600
- interest costs on investments (5%)	5 125	5 125	5 125
- labour costs	-18 375	-2 325	-49 528
Total extra annual costs (euros)	10 350	26 400	-20 803
Effect on cost price (euros per kg)	0.04	0.24	-0.06
as % of sales price	1.31%	7.68%	-2.14%

Previous analysis has shown that sales volume and labour costs per employee influence the effect on cost price of adhering to improved welfare practices. In Figure 27 the results of a sensitivity analysis are presented, which show that – depending on salary level – between a volume of 250 and 400 tonnes the effect on cost price drops below 5 euro cents/kg of fish. At average labour costs of 50 000 euros per FTE, break-even is achieved at a volume of around 650 tonnes.

Figure 27. Sensitivity analysis of sales volume and labour costs on the cost price of rainbow trout when adhering to improved animal welfare practices (euros/kg)



11.2.5. EUROPEAN SEA BASS/GILTHEAD SEA BREAM

11.2.5.1. EUROPEAN SEA BASS

11.2.5.1.1. Production of European sea bass

Table 57 shows the production quantity of European sea bass from aquaculture in major producing countries in the period 2009-2013.

Turkey is the largest producer with a 46 % share in 2013, followed by Greece (24 %), Spain (10 %) and Italy (5 %). These four countries accounted for 85 % of world production in 2013. Turkey has shown the most growth (45 %) between 2009 and 2013, followed by Spain (18 %). As with production quantity, Turkey is the largest producer by value, with a 40 % share, followed by Greece (25 %), Spain (13 %) and Italy (8 %).

Table 57. Production of European sea bass from aquaculture, 2009-2013 (1 000 tonnes live weight)

Country	2009	2010	2011	2012	2013	Change 2009-2013	Share of total, 2013
Turkey	46.6	50.8	47.0	65.5	67.9	46 %	46.2 %
Greece	33.6	39.9	37.1	35.8	34.9	4 %	23.7 %
Spain	12.7	11.5	17.5	14.5	14.9	18 %	10.2 %
Italy	6.7	6.5	6.7	6.7	6.7	0 %	4.6 %
Other countries	12.9	25.9	28.7	23.3	22.6	75 %	15.3 %
Total world	**112.5**	**134.5**	**137.1**	**145.8**	**147.0**	**31 %**	**100.0 %**

Source: FAO Global Fishery and Aquaculture Statistics version 2016.1.2

11.2.5.1.2. Export of sea bass

Table 58 shows the export quantity of sea bass as a fresh, chilled or frozen commodity from the major producing countries from 2009 to 2013. Around 50 % of world production is exported (including re-export).

Although it is the second largest producer, Greece is the largest exporter with a 40 % share of exports in 2013. Greece exported between 86 % and 96 % of its production in the period 2009-2013. Greece, Turkey (23 %), Spain (8 %) and Italy (3 %) accounted for 75 % of world export trade in 2013. Spain has shown the greatest growth in exports, albeit starting from a small base.

Table 58. Export of fresh, chilled and frozen European sea bass, 2009-2013 (1 000 tonnes)

Country	2009	2010	2011	2012	2013	Change 2009-2013	Share of total, 2013
Greece	29.0	35.9	32.2	34.2	31.6	9 %	40.3 %
Turkey	14.7	11.6	10.2	9.9	18.0	23 %	23.0 %
Spain	2.4	3.0	4.4	5.2	6.4	162 %	8.2 %
Italy	1.9	1.2	0.8	1.8	2.3	18 %	2.9 %
Others	13.6	15.1	15.6	17.2	20.1	48 %	25.6 %
Total world	**61.7**	**66.8**	**63.3**	**68.3**	**78.3**	**27 %**	100.0 %
% of world production	55 %	50 %	46 %	47 %	53 %		

Source: FAO Global Fishery and Aquaculture Statistics version 2016.1.2

Table 59 shows the export value of sea bass in the period 2009-2013. In total this export (including re-export) equals just over 50 % of the world production value. The figures for export value broadly reflect those for export quantity.

Greece, Turkey, Spain and Italy together accounted for 75 % of global export value in 2013. Export values fluctuate from year to year. Of the four countries, Spain showed the strongest growth in exports in the period 2009-2013.

Table 59. Export value of fresh, chilled and frozen European sea bass, 2009-2013 (USD million)

Country	2009	2010	2011	2012	2013	Change 2009-2013	Share of total, 2013
Greece	180	209	267	254	207	15 %	41.3 %
Turkey	65	52	58	57	98	52 %	19.6 %
Spain	20	25	35	43	52	167 %	10.4 %
Italy	13	8	8	9	15	12 %	2.9 %
Others	93	101	115	117	129	39 %	25.7 %
Total world	**370**	**395**	**483**	**482**	**501**	**35 %**	100.0 %
% of world production	56 %	51 %	56 %	50 %	53 %		

Source: FAO Global Fishery and Aquaculture Statistics version 2016.1.2

11.2.6. Gilthead sea bream

11.2.6.1. Production of gilthead sea bream

Table 60 shows the production of gilthead sea bream from aquaculture in the main producing countries for the period 2009-2013.

Greece (36 %), Turkey (23 %), Spain (12 %) and Italy (3.4 %) contributed 75 % of global production in 2013. Turkey showed a growth in production of 26 % over the period, whereas production in the three EEA States stagnated or decreased.

Table 60. Gilthead sea bream production from aquaculture, 2009-2013 (1 000 tonnes live weight)

Country	2009	2010	2011	2012	2013	Change 2009-2013	Share of total, 2013
Greece	60.5	57.2	51.3	53.5	55.8	-8 %	35.5 %
Turkey	28.4	28.2	32.2	30.7	35.7	26 %	22.7 %
Spain	23.2	20.4	15.1	16.6	18.9	-19 %	12.0 %
Italy	5.4	6.3	5.5	5.4	5.4	0 %	3.4 %
Other countries	18.5	30.4	30.2	34.9	41.2	122 %	26.3 %
Total world	**136.0**	**142.4**	**134.3**	**141.1**	**157.0**	**15 %**	**100.0 %**

Source: FAO Global Fishery and Aquaculture Statistics version 2016.1.2

The figures for the value of production correspond with those for production quantity.

11.2.6.2. Export of gilthead sea bream

Table 61 shows the export of fresh, chilled and frozen gilthead sea bream from the major producing countries in the period 2009-2013. Total exports (including re-export) equate to about 50 % of world production.

Greece — the largest producer — is also the largest exporter with a 54 % share of world exports. Greece, Turkey (25 %), Spain (7 %) and Italy (2 %) together accounted for 90 % of world exports in 2013. Exports from Turkey and Spain increased over the period, whereas those from Greece and Italy declined slightly.

Table 61. Export of fresh, chilled and frozen gilthead sea bream, 2009-2013 (1 000 tonnes)

Country	2009	2010	2011	2012	2013	Change 2009-2013	Share of total, 2013
Greece	48.4	47.0	38.1	43.7	47.5	-2 %	54.3 %
Turkey	7.3	7.4	9.5	14.1	21.9	201 %	25.0 %
Spain	4.7	4.0	5.9	5.1	6.1	31 %	7.0 %
Italy	2.1	2.1	1.6	0.9	2.0	-5 %	2.3 %
Others	3.4	3.4	4.8	7.4	7.9	132 %	9.1 %
Total world	**67.9**	**65.8**	**61.9**	**73.3**	**87.5**	**29 %**	97.7 %
% of world production	50 %	46 %	46 %	52 %	56 %		

Source: FAO Global Fishery and Aquaculture Statistics version 2016.1.2

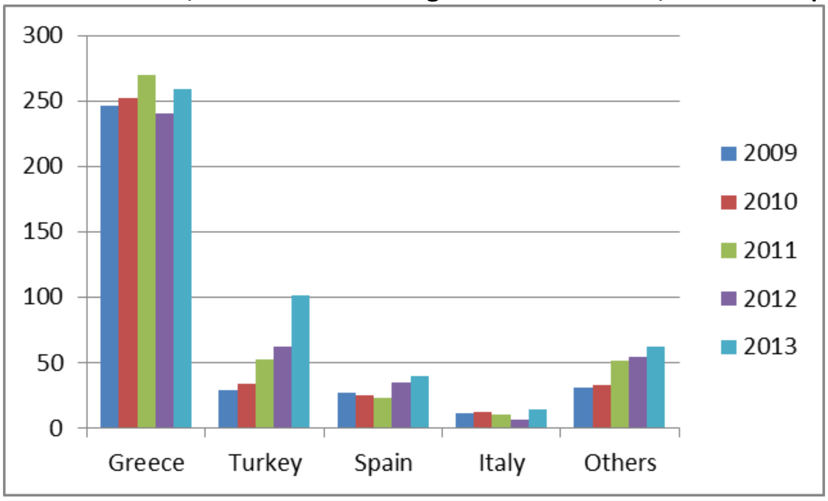
Table 62 shows the export value of gilthead sea bream in the period 2009-2013. The export value figures broadly reflect those on export quantities shown above. Greece and Italy show a slight increase in the value of exports between 2009 and 2013 despite slight decreases in export quantity.

Table 62. Export value of fresh, chilled and frozen gilthead sea bream, 2009-2013 (USD million)

Country	2009	2010	2011	2012	2013	Change 2009-2013	Share of total, 2013
Greece	246	252	270	240	259	5 %	54.0 %
Turkey	30	34	53	62	102	244 %	21.2 %
Spain	27	26	24	35	40	47 %	8.4 %
Italy	12	13	11	6	14	18 %	3.0 %
Others	31	34	52	55	62	100 %	13.0 %
Total world	**348**	**359**	**412**	**401**	**479**	**38 %**	99.6 %
% of world production	48 %	43 %	47 %	50 %	53 %		

Source: FAO Global Fishery and Aquaculture Statistics version 2016.1.2

Figure 28. Export value of fresh, chilled and frozen gilthead sea bream, 2009-2013 (USD million)



Source: FAO Global Fishery and Aquaculture Statistics version 2016.1.2

11.2.6.3. Structure and finances of average sea bass and sea bream farms

As data sources combine costs and revenues for the on-farm activities for sea bass and sea bream, a combined analysis is presented for both species.

The structure and finances of average sea bass and sea bream farms in Italy and Spain in 2009 and 2012, and average aquaculture farms in Greece in 2014 are presented in Table 63.

The STECF 14-18 database combines the data of sea bass and sea bream enterprises in 2009 and 2012, and the STECF 16-19 database provides data for total aquaculture in Greece in 2014

The table shows that the average enterprise in Spain produced about three times as much sales volume in 2009 and 2012 as the average enterprise in Italy with about five times the number of employees. However, the total value of assets is only just over 60 % higher. The structure and finances in Greece in 2014 resemble the average enterprise in Spain in 2009 and 2012 to a great extent. Despite subsidies and other income, the net farm income is mostly negative.

Table 63. Structure and finances of average sea bass and sea bream farms (1 000 euros)

Data per enterprise	Greece		Italy		Spain	
	2009	2014	2009	2012	2009	2012
Structure						
Number of enterprises	337	248	93	51	72	55
Production						
Total sales volume (tonnes)	286	476	150	201	437	601
Employment						
Total employees		20.7	3.3	5.9	17.1	22.6
Total FTE		18.7		2.0	13.3	18.0
Capital Value						
Total value of assets		4 840	3 390	2 174	3 639	5 327
Income						
Turnover	1 104	2 473	1 340	1 418	2 148	3 850
Subsidies and other income		270	94	44	278	252
Operating Costs						
Wages and salaries		469	221	223	429	550
Feed costs		930	450	267	1 087	1 835
Livestock costs		786	205	273	506	668
Other operational costs		543	505	218	661	1 112
Capital Costs						
Depreciation and financial costs		257	178	142	115	121
Net farm income						
Income minus operating and capital costs		-242	-124	339	-373	-184

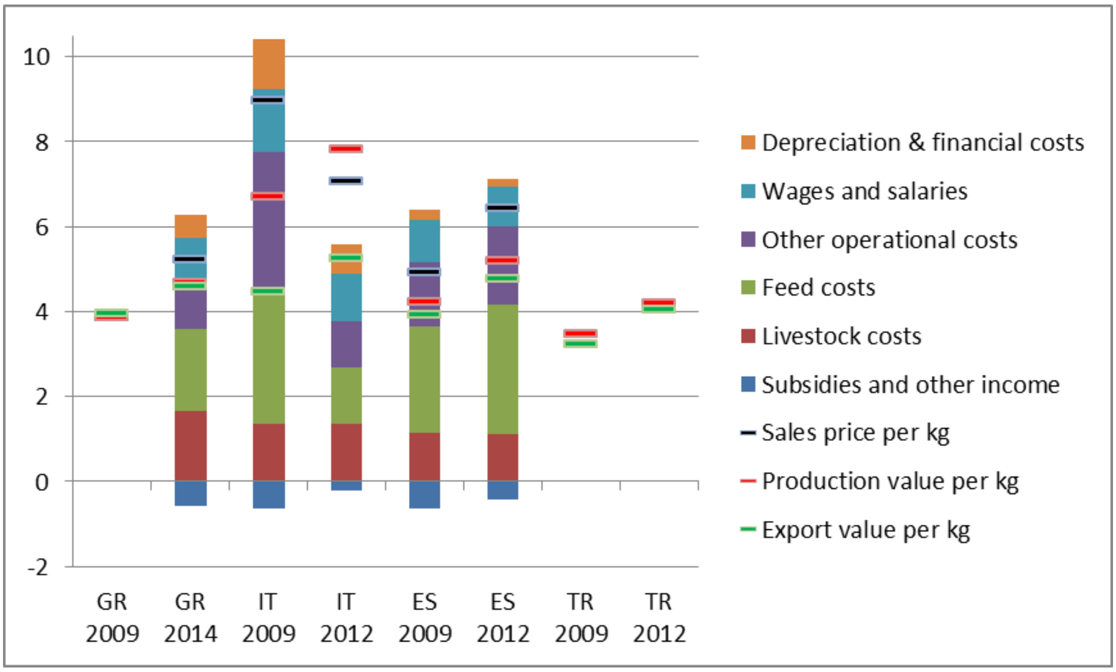
Sources: Scientific, Technical and Economic Committee for Fisheries (STECF) - Economic Report of EU aquaculture sector (STECF 14-18 for Italy and Spain, & STECF 16-19 for Greece in 2014)

Figure 29 shows that the production cost of sea bass and sea bream in Greece (GR) in 2014 amounts to 5.70 euros/kg. In Italy (IT) and Spain (ES) in 2012 it was respectively 5.36 and 6.71 euros/kg. In nearly all cases, sales prices are not sufficient to cover costs, so subsidies and other income are needed to survive.

For comparison, the production value (= sales price) and export value per kg from FAO Statistics are presented. Contrary to the other fish species in this study, sales prices from the STECF database are mostly higher than the production values from the FAO statistics, possibly because of a different weighting between sea bass and sea bream in the two data sources. Export value is expected to be higher, as the cost of slaughtering, packaging and transportation are included. However the opposite is the case, probably because of higher prices for fresh produce on the domestic market.

Overall, production value in EEA States varies around 5.50 euros/kg against about 3.80 euros/kg in Turkey (TR). The difference in export value is much smaller: roughly 4.50 euros/kg in EEA States and 3.60 euros/kg in Turkey.

Figure 29. Cost of sea bass and sea bream production (euros)



Sources: Scientific, Technical and Economic Committee for Fisheries (STECF) - Economic Report of EU aquaculture sector (STECF-14-18 & STECF 16-19 for Greece 2014); production and export values are calculated from FAO Global Fishery and Aquaculture Statistics, version 2016.1.2

11.2.6.4. Improved welfare

For European sea bass and gilthead sea bream, two alternative methods to improve fish welfare are considered: electrical stunning before dewatering and electrical stunning after dewatering, both followed by putting them on ice, as is common practice. Both systems have successfully been implemented on boats.

Table 64 shows that in the worst case scenario total required additional investments range between 140 000 for electrical stunning after dewatering and 190 000 euros for electrical stunning after dewatering. There is no saving of labour and the annual costs of the extra investments varies from 22 000 to 27 000 euros. The effect on cost price is quite limited (0.5-2.0 %), even for relatively small volume producers as in Italy. However, the doubtful financial situation on most of these farms might prevent producers from investing in welfare-friendly slaughter methods.

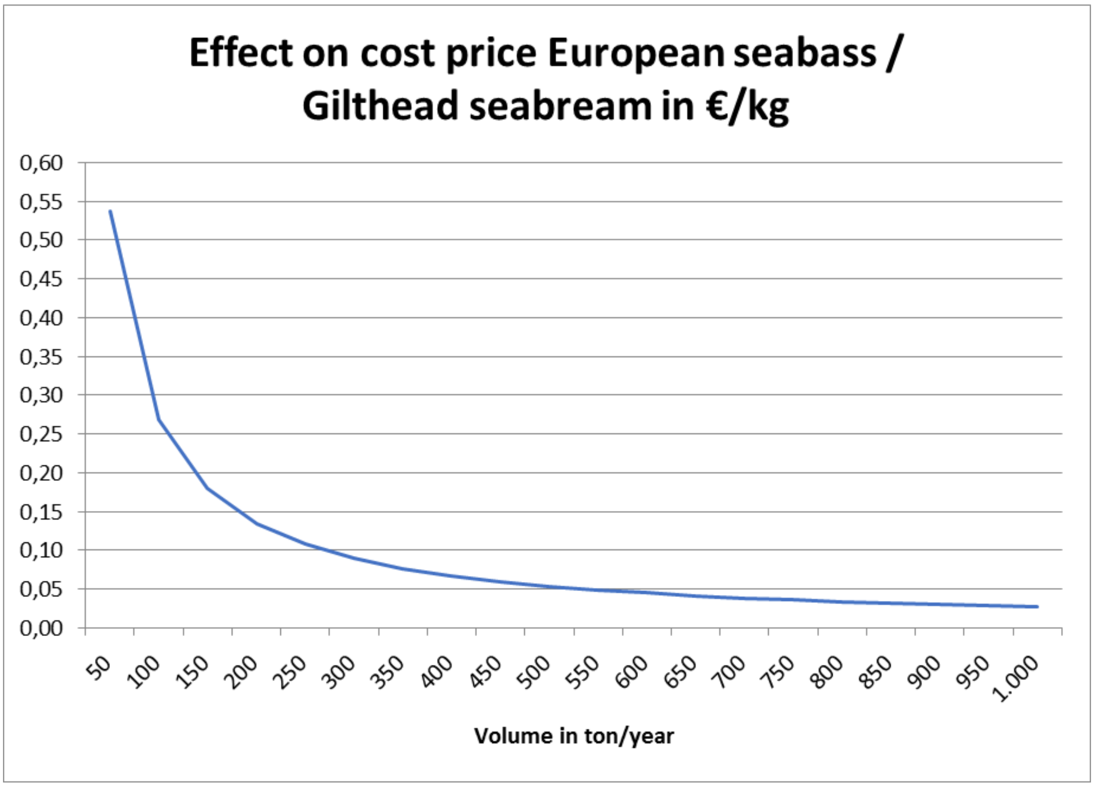
Table 64. Cost of adhering to improved animal welfare practices – European sea bass / gilthead sea bream (euros)

Per enterprise	Electrical stunning before dewatering			Electrical stunning after dewatering		
	Greece	Italy	Spain	Greece	Italy	Spain
	2014	2012	2012	2014	2012	2012
Total sales volume (tonnes)	476	201	601	476	201	601
Sales price (euros per kg)	5.19	7.05	6.40	5.19	7.05	6.40
Transport:						
water quality equipment	common practice			common practice		
Stunning:						
pump 2-3 ton/hr	50 000	50 000	50 000	50 000	50 000	50 000
electro stunner in water on harvest boat 5 ton/hr	140 000	140 000	140 000			
electro stunner after dewatering 2-20 ton/hr				40 000	40 000	40 000
dewater unit after stunning	5 000	5 000	5 000			
dewater and singulation unit before stunning				50 000	50 000	50 000
Killing:						
Decapitation robot	not applicable			not applicable		
Total extra investments (euros)	195 000	195 000	195 000	140 000	140 000	140 000
Extra annual costs (euros):						
- depreciation and maintenance	22 000	22 000	22 000	18 000	18 000	18 000
- interest costs on investments (5%)	4 875	4 875	4 875	3 500	3 500	3 500
- labour costs	-	-	-	-	-	-
Total extra annual costs (euros)	26 875	26 875	26 875	21 500	21 500	21 500
Effect on cost price (euros per kg)	0.06	0.13	0.04	0.05	0.11	0.04
as % of sales price	1.09%	1.90%	0.70%	0.87%	1.52%	0.56%

As in other cases, sales volume influences the effect on cost price of adhering to improved welfare practices.

Figure 30 presents the results of a sensitivity analysis, which show that around a volume of 550 tonnes the effect on cost price is less than 5 euro cents per kg of fish.

Figure 30. Sensitivity analysis of sales volume on the cost price of European sea bass / gilthead sea bream when adhering to improved animal welfare practices (euros/kg)



12. MAIN FINDINGS AND CONCLUSIONS

12.1. WELFARE PRACTICES

The study examined the welfare during transport and at slaughter of five species of fish farmed in the EEA. OIE standards were used as a benchmark for good welfare practices.

12.1.1. TRANSPORT

The two main methods of transporting live fish in the EEA were assessed: overland transport by truck and sea transport by well-boat. In cases where a truck or containers were taken by ferry to sea cages, this was still considered as transport by truck as the fish were not transferred from the tank or container to the hull of the well-boat. Factors causing stress in fish during transport include density changes, handling, water movement, noise, vibrations and poor water quality. The overriding factor regarding density is to maintain water quality throughout the journey. The tolerance to stress varies between the species. Good handling by well-trained staff is essential to minimising stress and achieving good welfare practices, especially during loading and unloading of the transport vehicles.

Regarding transport to on-growing facilities (for Atlantic salmon, European sea bass and gilthead sea bream), it was found that OIE standards are likely to be met for the three species in the relevant case-study countries (Norway, United Kingdom, Ireland, Greece, Spain, Italy).

For transport of marketable fish for slaughter, OIE standards are met for Atlantic salmon and rainbow trout (in Norway, United Kingdom, Ireland, Denmark, France, Italy and Poland). For common carp, transport for slaughter is considered to meet Council Regulation (EC) No 1/2005, but only partly OIE standards in Germany and Poland; whilst in the Czech Republic, OIE standards are met for transport of common carp for slaughter.

12.1.2. SLAUGHTER

The OIE advises the use of electrical or mechanical stunning and killing methods for farmed fish. However, the use of these methods is not always practical throughout all farming systems in the EEA. Killing by a manual blow to the head is acceptable when carried our correctly and instantaneously after exposure of fish to air. Other methods including live chilling with carbon dioxide, carbon dioxide stunning, chilling in ice water followed by electrical stunning, and asphyxia in ice do not meet OIE standards.

The level of adherence to OIE standards at slaughter was found to vary according to the species.

OIE standards are met for percussion of Atlantic salmon in Norway, the United Kingdom and Ireland. However, some practices that do not fully adhere to OIE standards are still in use: in Norway 70-75 % of salmon are not oriented prior to electrical stunning after dewatering (note this percentage is decreasing); and live chilling combined with carbon dioxide is still used, although it is being phased out. It should be noted that electrical stunning of salmon should be followed by an effective killing method to prevent recovery; decapitation or percussion are effective. Carbon dioxide stunning is still used to a limited extent in Ireland, but its use is declining.

OIE standards are only partly achieved for the slaughter of common carp in Poland, Czech Republic and Germany. The most common method is manual percussion (a blow to the head). However, in Poland the carp are exposed to the air for a maximum of 10 minutes, which causes stress. Electrical stunning is also used in Poland, Czech Republic and Germany, but there is a lack of information on the effectiveness of the equipment for this method.

For rainbow trout, OIE standards are partly achieved in Denmark, France and Italy, but they are not achieved in Poland. Electrical stunning is used in Denmark and Italy. However, data on the construction of the equipment is scarce and therefore it is not known whether OIE standards for electrical stunning are met. Manual percussion of rainbow trout meets OIE standards, provided it is carried out correctly. Asphyxia in ice is used in Denmark and Poland, and does not meet OIE standards. In France, chilling in ice water followed by electrical stunning, and CO_2 stunning (to a limited extent) are used, neither of which meet OIE standards.

The vast majority of sea bass and sea bream are slaughtered in Greece, Spain and Italy by asphyxia in ice, which does not adhere to OIE standards. Electrical stunning is used in Greece, but it is still at an infant stage

Overall, from the study findings it became clear that the industry is gradually but continuously improving fish welfare.

12.2. SOCIO-ECONOMIC ANALYSIS

12.2.1. AQUACULTURE PRODUCTION

EEA aquaculture accounted for just under 10 % of world production by volume and increased by 9 % over the reference period (2009-2013). The major non-EEA producers are China (with 60 % of world production), Chile, Turkey and Canada; all these countries showed significant growth over the reference period. The contribution of aquaculture to total world fish production reached 42 % in 2012 and is projected to increase rapidly.

In addition to differences between the five species studied and between environments (cold-water marine, Mediterranean marine, freshwater), the variation in the scale of enterprises and the production methods are relevant factors for welfare, and were considered in the socio-economic analysis. However, difficulties in obtaining precise financial data for commercial enterprises limited the financial analysis at enterprise level.

12.2.2. COST OF ADHERING TO GOOD WELFARE PRACTICES

12.2.2.1. TRANSPORT

Water quality equipment was identified as an essential investment for achieving good fish welfare practices during transport. As the installation and use of such equipment during transport of both juveniles for on-growing and fish to slaughter is already common practice for the five species in the EEA, no additional investments are required to meet OIE standards during transport. Transport was therefore not considered further in the economic analysis.

12.2.2.2. SLAUGHTER

For the economic analysis, it was assumed that every fish farm required certain equipment in order to meet OIE welfare standards during stunning and killing, as described below for each species. For the purposes of the analysis, it was assumed that every farm needs to purchase such equipment – the so-called 'worst case' scenario.

Atlantic salmon

For Atlantic salmon, investment costs include either an electric stunner or a mechanical stunner, plus a decapitation robot.

The additional costs for adopting improved welfare practices in the salmon industry are relatively small – about 2 euro cents/kg or 0.5 % of the sales price in UK, and no more than 9 euro cents/kg or less than 1.5 % of the sales price in Ireland. In slaughterhouses with high throughput and high labour costs, such as in Norway, the investment might even result in cost savings.

For the salmon-producing EEA states, the effect of improving welfare practices during slaughter on the cost price of the salmon is limited.

Common carp

The selected investments to improve the welfare of common carp at slaughter in line with OIE standards were electrical stunning – either before or after dewatering – followed by manual gill cutting. For the cheaper of the two methods – electrical stunning before dewatering – the extra cost was 6 euro cents/kg in Poland, 41 euro cents/kg in Romania, and 58 euro cents/kg in Germany. As a percentage of the sales price, the figures were 2.8 %, 24.4 % and 24.0 % respectively.

Economies of scale in slaughter volume at slaughterhouses have a substantial effect on the cost of welfare measures during slaughter. Especially in EEA countries with relative small-scale production, this might lead either to collaboration between farms, or an increase of volume produced by farms.

As export (including re-export) accounts for only a very small proportion of world carp production, the effects of welfare measures on international competitiveness are expected to be limited (although the impacts on cost price can be considerable).

Rainbow trout

The investment requirements to meet OIE standards for the slaughter of rainbow trout are: 1) electrical stunning before dewatering, and; 2) percussive stunning after dewatering, both followed by manual gill cutting.

The additional costs of electrical stunning before dewatering are relatively small: 4 euro cents/kg in Denmark and 24 euro cents/kg in France. In Italy, where slaughterhouses have high throughput and high labour costs, this method was calculated to result in cost savings of 6 euro cents/kg. Percussive stunning is a more expensive option.

For small scale farms, such as in France, co-operation between farms and slaughter in a dedicated slaughterhouse might decrease the negative impact on cost price.

European sea bass and gilthead sea bream

The investments considered to improve welfare at slaughter were: 1) electrical stunning before dewatering, and; 2) electrical stunning after dewatering, both followed by chilling in a slurry of ice and sea water.

The resulting increase in cost price varies within a range from 0.5-2.0 % between countries according to the size of enterprises. Although the cost increase is quite modest, even for relatively small volume producers as in Italy, the doubtful financial situation on most of these farms might prevent producers from investing.

12.2.3. IMPACT ON COMPETITIVENESS

Even if every aquaculture farm has to acquire its own means of transportation and primary processing – the 'worst case' scenario – the effect of adhering to improved animal welfare practices on the cost price for the average fish farm in the case-study countries is quite limited in most cases. Nevertheless, low or negative income – as was found to be common on carp and sea bass/sea bream farms during the reference period – might prevent enterprises from investing 150 000 – 200 000 euros in improved animal welfare practices.

On relatively small-scale farms – like the average carp farm in Germany and Romania, and the average trout farm in France – the effect on cost price can be substantial. In these cases, co-operation between farms, or the use of specialist transporters and slaughterhouses, will increase the throughput of fish and thus reduce costs. For trout in Germany, for example, the use of specialised abattoirs is already common practice.

In situations where investments in improved animal welfare practices can be combined with labour saving, such as in salmon and portion-sized trout operations, a cost reduction might even occur, as is the case on relatively large scale salmon farms in Norway and trout farms in Italy.

Figure 31 and Figure 32 illustrate the effect of improved welfare practices on the cost price of the five species in the case-study countries.

Figure 31. Impact of achieving improved animal welfare practices on the cost price of farmed fish in the case-study countries (euros/kg)

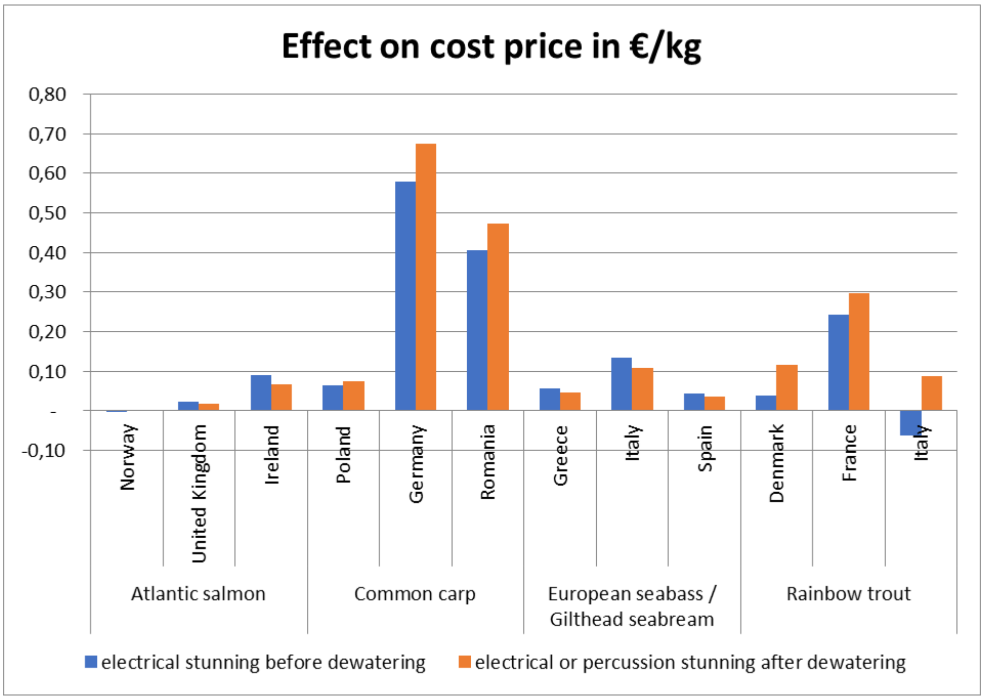
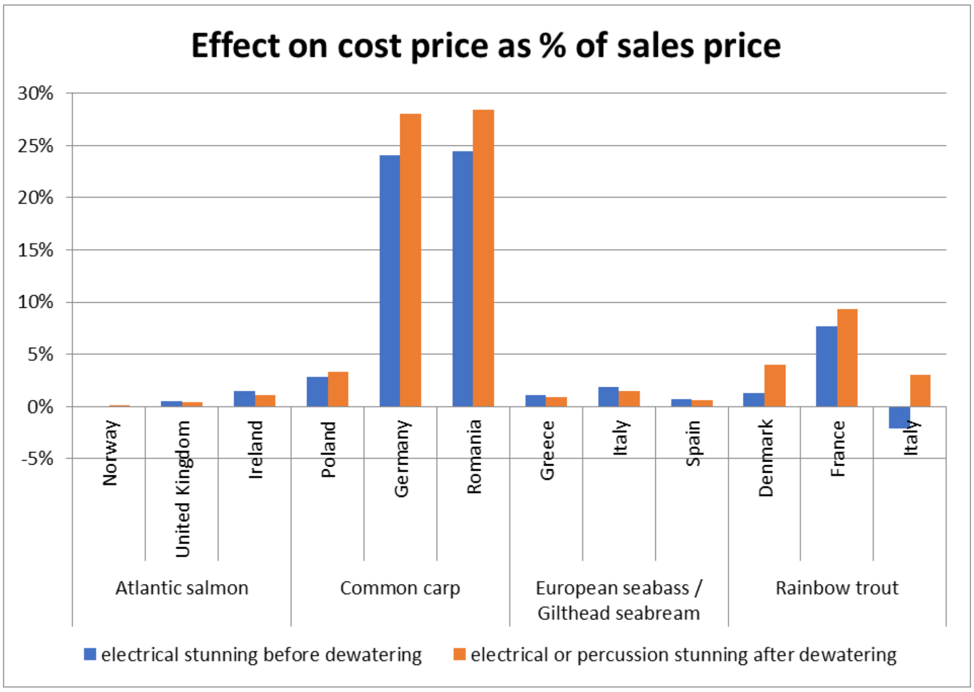


Figure 32. Impact of achieving improved animal welfare practices on the cost price of farmed fish in the case countries (% of sales prices)



For salmon, the savings in labour costs outweigh the additional investments in improved welfare and result in a net cost reduction.

For carp, export (including re-export) accounts for only a very small part of world carp production – around 0.5 % in 2009-2011 and approximately 2.0 % in 2012-2013. Most carp from aquaculture is therefore processed and consumed in the country of origin. Therefore, the effects of welfare measures on competitiveness in carp are expected to be limited, although the impacts on cost price can be considerable.

12.2.4. FACTORS THAT MAY INFLUENCE THE APPLICATION OF IMPROVED ANIMAL WELFARE PRINCIPLES

The impetus to improve welfare during transport and protection of welfare at slaughter is influenced by a growing concern in society about animal welfare. Implementation of stunning of Atlantic salmon showed this may lead to an increase in efficiency of the process of stunning and killing (F. Kjølås, personal communication).

The EU project BENEFISH (project no. 44118) developed a bio-economic model to estimate the costs and benefits of welfare interventions at a farm level. The BENEFISH project showed that welfare interventions and business in aquaculture can be a win-win benefit.

For Atlantic salmon, electrical stunning before dewatering and percussion stunning after dewatering require additional investments ranging between 410 000 and 425 000 euros per slaughter facility. Overall, there is very little effect on cost price (less than 1.5 %). It was also shown that, when labour costs are relatively high, the implementation of welfare practices even might result in a net cost reduction: the savings in labour costs outweigh the additional investments.

For common carp, two alternative methods to improve fish welfare during slaughter are considered: electrical stunning before dewatering and electrical stunning after dewatering, both followed by manual gill cutting. In case of relatively large volume producers – as in Poland – the effect on cost price per kg of fish is quite limited (around 3.0 %). Low or even negative income on the majority of these farms will probably prevent producers in carp farming from investing if these additional costs are not compensated by higher revenues. In Germany, carp are mostly slaughtered in specialised abattoirs, which process the fish from several farms. The additional costs per kg of fish will be lower compared to the situation in which each farm has its own slaughter facilities.

For rainbow trout, two alternative methods to improve fish welfare are considered: electrical stunning before dewatering and percussion stunning after dewatering, followed by manual gill cutting. For relatively large volume producers – as in Italy, Denmark and Poland – the effect on cost price is quite limited (less than 3.0 %). For small-scale farms in France, the effect on cost price is particularly high – an additional 25 to 30 euro cents/kg of fish, which is equivalent to about 8.5 % of the sales price. At average labour costs of 50 000 euros per full-time employee, the break-even is achieved at a volume of around 650 tonnes. Therefore, a significant proportion of total production is required to reach break-even for such investments.

For European sea bass and gilthead sea bream, two alternative methods to improve fish welfare are considered: electrical stunning before dewatering and electrical stunning after dewatering, both followed by chilling on ice, as is common practice. The effect on cost price is quite limited (0.5-2.0 %), even for relatively small volume producers as in Italy. However, the doubtful financial situation on most of these farms might prevent producers from investing in welfare friendly slaughter methods.

The impact of improved animal welfare practices on product quality is complex. Improved welfare practices such as percussion and electrical stunning can lead to carcass damage, but this can be avoided or minimised by establishing specifications for effective stunning and killing that also ensure no or minimal impact on product quality. Another example is that analysis of product quality of electrically stunned sea bass showed that product quality is similar to that of sea bass killed in ice water without prior stunning. For carp, it was shown in an experimental setting that manual percussion, as applied in Poland, did not induce major differences in product quality compared to an experimental method for electrical stunning. This study did not identify that product quality is in general negatively or positively affected by improving welfare practices; the effects may vary between husbandry practices and between the fish species under consideration. As fish welfare becomes more widely acknowledged as a factor in total product quality, it can be expected that more attention will be given to improving it in this context.

12.2.5. LIMITATIONS OF THE FINDINGS

The economic analysis was performed using the available information on the costs of equipment required for improving welfare during transport and at slaughter. Actual costs at the time of purchase may vary.

The analysis is based on the average enterprise for each species in each of the case-study countries. However, it is assumed that enterprises with high throughput achieve economies of scale. The financial return on the investments will also differ substantially between fish species.

For enterprises with lower annual production volumes, the investment costs are substantially higher than for larger scale operations. The capacity of the identified equipment is such that it might be idle for significant periods of time. It may be that alternative – lower cost – equipment will become available for smaller-scale facilities. However, no information on such alternatives was available at the time of the study.

A further limitation of the findings concerns the quality of data that was obtained during the study, particularly financial and commercially sensitive information. This was mainly due to a low response rate from industry, which is understandable but nevertheless affected the precision of the calculations. It should also be noted that the study focused on a specific reference period, 2009-2013, which may not reflect trends over a longer period, or over the period since.

The economic aspects associated with specific welfare practices are based on a narrow time range. While the data give an initial indication of costs at the time of survey, wider extrapolation to other years, volumes and species should not be considered on the basis of the data in this study alone. The likely influence of the economic crisis on the performance of the sector during the reference period should also be taken into account.

Nevertheless, within these limitations it has been possible to produce meaningful trends and findings.

12.2.6. ANALYSIS OF WHETHER PRICE DIFFERENCES MAY BE RELATED TO MORE HUMANE PRACTICES

Differences in production costs for the species analysed are mainly due to the structure of the industry in each of the case-study countries. The analysis clearly indicates benefits of scale: larger farms have lower unit production costs.

This research indicated that implementing improved welfare practices has only very small effect on the cost of production. Other factors that affect the cost of production, such as operating costs, feed costs and labour costs are responsible for the greatest differences between countries.

This research also shows the effect on production cost of implementing improved welfare practices is largest on smaller farms.

Product quality can be affected by improving welfare practices, although the effects may vary between practices and fish species under consideration. There is concern that some improved welfare practices, such as electrical stunning and percussive stunning can impair fish meat quality. However, there is evidence that such negative effects can be mitigated. As explained in section 12.2.4, it seems likely that further developments in fish welfare, particularly at slaughter, can be designed to produce benefits, or at least no adverse effects, in product quality.

For salmon and trout production, implementing improved welfare practices especially in larger enterprises leads to savings in labour costs that outweigh additional investments costs.

Carp is mainly consumed in the domestic market. Differences in cost price due to implementing animal welfare practises are largest in small farms, but are unlikely to affect the export position of a country. However within a country their might be a competitive disadvantage for smaller farms.

Regarding European sea bass and gilthead sea bream production in Greece, Italy and Spain; sales prices during the reference period were not sufficient to cover production costs for many farmers. Subsidies and other income were needed to survive. Turkish production and export of these two species has been increasing substantially in the last decade. However the export value is below that of the EEA countries, indicating that Turkey is not able to realise the same market prices as EEA countries.

13. Annexes

ANNEX 1 – List of stakeholders

The list of stakeholders in each case-study country is presented below. Producers have not been included in the list for data protection reasons.

List of Stakeholders			
Country	**Species**	**Stakeholder Type**	**Organisation**
Czech Republic			
CZ	All	CA	State Veterinary Administration, Department of Animal Health and Animal Welfare
CZ	All	CA	Ministry of Agriculture
Germany			
DE	All	CA	Federal Ministry of Agriculture
DE	All	Research	Institute for Inland Fisheries in Potsdam Sacrow
DE	All (carp)	Research	Institute for Inland Fisheries in Starnberg, Bavaria
Denmark			
DK	Rainbow trout	Equipment	FREA A/S - KÆRHEDE DAMBRUG APS
DK	All	CA	Danish Veterinary and Food Administration (Ministry of Environment and Food of Denmark)
Spain			
ES	Sea bass/sea bream	CA	Magrama, Ministery of agriculture, food and environment, G Sanidad e Higiene Animal y Trazabilidad
France			
FR	All	CA	Ministry of Agriculture
Greece			
GR	All	CA	Ministry of rural development and food general vet. directorate of animal health
Ireland			
IE	All	CA	Department of Agriculture, Food and Marine, Marine Institute Ireland
Italy			
IT	All	CA	Ministry of Health/Directorate General for Animal Health and Veterinary Medicines
IT	All	CA	Istituto Zooprofilattico Sper.le delle Venezie
Norway			
NO	All (mainly salmon)	CA	Ministry of Agriculture and Food (Resp. Animal Welfare)
NO	All (mainly salmon)	CA	Ministry of Trade, Industry and Fisheries (Resp. Fish Welfare)
NO	All (mainly salmon)	CA	The Norwegian Food Safety Authority (Enforcement)
NO	All (mainly salmon)	NGO	Dyrevernalliansen (Norwegian Animal Protection Alliance)
NO	All (mainly salmon)	Research	Nofima (research)
NO	All (mainly salmon)	Research	Veterinærinstituttet (research)
NO	All (mainly salmon)	Research	SINTEF (research)
NO	All (mainly salmon)	Research (?)	Kontali Analyse A/S (statistical analysis; also of Aquaculture)
NO	All	Stunning & Killing Equipment	Seaside
NO	All	Transport	Norwegian association of wellboat owners, Brønnbåteiernes Forening
NO	All	Equip't & transport	Stranda Prolog AS

List of Stakeholders			
Country	**Species**	**Stakeholder Type**	**Organisation**
NO	All	Equipment	Melbu Systems – handling equipment
Poland			
PO	All	CA	Ministry of Agriculture and Rural Development
United Kingdom			
UK	All	CA	Aquatic Animal Health, Safeguarding Plant and Animal Health Directorate, Department for Environment, Food and Rural Affairs (DEFRA)
UK	All	CA	CEFAS, Fish Health Inspectorate
UK	All	CA	The Scottish Government Farming and Rural Development and Aquatic animal health at Marine Scotland in Edinburgh
UK	All		Fisheries Research Services, Aberdeen Marine Laboratory
UK	All	NGO	WAP
UK	All	NGO	Eurogroup for Animals
UK	All	NGO	CIWF
UK	All	NGO	RSPCA (Freedom Food)
UK	All	NGO	Fairfish
UK	All	Transport	Sølvtrans (Norwegian company operating in UK)
UK	All	Stunning Equip't	ACE Aquatec

ANNEX 2 – APPROVED QUESTIONNAIRES AND INTERVIEW TEMPLATES

This Annex presents approved interview questionnaires for competent authorities, sector representatives, NGOs/animal welfare organisations, and sector representatives. The questionnaires were discussed and approved by the Commission prior to the launch.

The Annex also includes interview templates, which were used to structure interviews carried out with companies involved in the transport and slaughter of fish in the case study countries. These templates were made available on-line. The templates were not specifically approved by the Commission.

General information for interviewees

Objective and background

The IBF Consortium, including the IBF Consumer Policy Centre, VetEffecT and Wageningen University & Research (WUR) has been awarded the contract for the study on "Welfare of farmed fish: Common practices during transport and slaughter (SANTE/2016/G2/SI2.736160).

"The aim of the study is to gather information on current animal welfare practices prevailing in European aquaculture as regards the transport and slaughter of farmed fish. Information will also be gathered on national rules and on the use of international standards, best practices or voluntary assurance schemes and/or code of practices. The data collected will be analysed to illustrate to what extent fish welfare issues are addressed or remain unresolved. In addition, factors which may influence the use of animal welfare principles such as the economic situation of the aquaculture industry, trade issues and available knowledge among business operators will be assessed."

Specific Objectives

1. Review the state of play regarding the welfare of farmed fish during transport and at the time of killing under current practices in Europe, using international standards as a benchmark.
2. Collect information on socio-economic aspects of the aquaculture sector and assess the costs and benefits of adhering to good animal welfare practices[51].
3. Describe and evaluate factors that promote, restrict or prevent the use of humane transport[52], handling, stunning and killing methods by the sector, such as the availability of commercial equipment, knowledge base, trade and the distribution of small and medium-sized enterprises (SMEs).
4. Determine any positive and negative effects that the addressing of animal welfare issues may have on the competitiveness of enterprises.

The study will investigate the main fish species that are produced in European aquaculture: Atlantic salmon, common carp, rainbow trout, European sea bass and gilthead sea bream.

The study will be limited to the main aquaculture producing EU Member States and other States of the European Economic Area (EEA).

[51] Existing benefits, e.g. better fish meat quality due to fish that are not stressed at time of killing or existing competitive advantages for the image of the final product resulting in premium prices are addressed. Potential benefits of improved welfare will not be addressed.
[52] Note that humane transport of fish implies optimal transport with regard to fish welfare

The questionnaires and interview templates used for the survey are included below as embedded pdf documents. Clicking on the icon will open the pdf file.

Questionnaire for competent authorities

Questionnaire EEA CAs

Questionnaire for sector representatives

Questionnaire Sector Representatives

Questionnaire for NGOs/animal welfare organisations

Questionnaire NGOs/ Organisations

Interview template for industry regarding transport

Interview Template Industry - Transport

Interview template for industry regarding stunning and killing

Interview Template Industry - Stun-Kill

ANNEX 3 – MEMBERS OF FOCUS GROUPS

Below we present the composition of the focus groups, excluding personal details

Focus group for Atlantic salmon

Focus group – Atlantic salmon		
Country	**Stakeholder**	**Type**
Norway	Norwegian Food Safety Authority	CA
Norway	The Research Council of Norway	CA
Ireland	Marine Institute	CA
UK	RSPCA	NGO
UK		Industry
Ireland	Marine Institute	Institute
UK		NGO
Norway	Norwegian University of Science and Technology, Alesund, Norway	University

Focus group for common carp

Focus group - common carp		
Country	**Stakeholder**	**Type**
Czech Republic	State Veterinary Administration	CA
Poland	General Veterinary Inspectorate	CA
Germany	Federal Ministry of Food and Agriculture (BMEL)	CA
Czech Republic		Industry
Poland		Industry
Poland		Industry
Germany	Naturland	NGO
Germany	Verband der Deutschen Binnenfischerei und Aquakultur e. V.	Expert
Poland		Expert
Czech Republic	University Vodnany	Expert

Focus group for rainbow trout

Focus group - rainbow trout		
Country	**Stakeholder**	**Type**
Denmark	Danish Veterinary and Food Administration (Ministry of Environment and Food)	CA
Italy	Istituto Zooprofilattico	CA
Denmark		Industry
Denmark		Industry
France		Industry
Italy	Associazione piscicoltori Italiani	Association
International (head office Belgium)	Eurogroup for animals	NGO
Denmark	University of Copenhagen	Expert
Denmark	Institute of Food and Resource Economics (University of Copenhagen)	Expert

Focus group for sea bass and sea bream

Expert group – sea bass/sea bream		
Country	**Stakeholder**	**Type**
Greece	Ministry of Rural Development and Food	CA
Greece	Agricultural University of Athens	CA
Spain	Ministry of Agriculture and Fisheries, Food and Environment	CA
Italy	Ministry of health	CA
Greece		Industry
Spain		Industry
UK	CIWF	NGO
Greece	University of Crete	Expert
Spain	IRTA	Expert
Spain	Dpt. Administración de Empresas, Universidad de Cantabria	Expert

ANNEX 4 – LITERATURE SEARCH, WEBSITES AND REFERENCES

Literature search

For the description of current practices during transport and at slaughter, a comprehensive literature search was performed, using the Aquatic Sciences and Fisheries Abstracts (ASFA) database. This literature search was supplemented by a search in Google.

The search queries are presented below. Within each a query we narrow the results to obtain data per fish species per country.

For slaughter practices two search queries were used:

1

("Atlantic salmon" OR "Salmo salar" OR "common carp" OR "Cyprinus carpio" OR "rainbow trout" OR "Oncorhynchus mykiss" OR seabass OR "sea bass" OR "Dicentrarchus labrax" OR "sea bream" OR seabream OR "Sparus aurata") AND (welfare OR "well being" OR well-being OR wellbeing OR stress OR humane OR unconscious OR unconsciousness OR insensible OR insensibility OR EEG OR "brain function" OR "brain activity" OR electrophysiology OR electrophysiological OR behaviour OR behavioural OR behavior OR behavioral) AND (slaughter OR slaughtering OR kill OR killing OR pre-slaughter OR preslaughter OR percussion OR percussive OR "percussive stun" OR "percussive stunning" OR concussion OR concussive OR "concussive stunning" OR "concussive stun" OR stun OR stunning OR chilling OR bleeding OR bled OR electronarcosis OR electro-narcosis OR asphyxia OR asphyxiation OR exsanguination OR "carbon dioxide" OR evisceration OR eviscerate OR eviscerated OR decapitation OR decapitate OR decapitated OR spiking OR coring OR "ike jime" OR shooting OR shot)

2

("Atlantic salmon" OR Salmo salar OR "common carp" OR "Cyprinus carpio" OR "rainbow trout" OR "Oncorhynchus mykiss" OR seabass OR "sea bass" OR "Dicentrarchus labrax" OR "sea bream" OR seabream OR "Sparus aurata") AND ("carcass quality" OR carcass OR quality OR "flesh quality" OR flesh OR fillet OR "fillet quality" OR defect OR "carcass damage" OR "rigor mortis" OR rigor OR "product quality" OR product OR colour OR color OR pH OR "liquid holding capacity" OR "liquid-holding capacity" OR "water-holding capacity" OR "water holding capacity" OR texture OR sensory OR flavour OR flavor OR odour OR odor OR off-odour OR off-odor OR off-flavour OR off-flavor OR TMA OR TVB OR TMAO OR nucleotide OR K-value OR freshness OR "shelf life" OR shelf-life OR "K value" OR appearance) AND (slaughter OR slaughtering OR kill OR killing OR pre-slaughter OR preslaughter OR percussion OR percussive OR "percussive stun" OR "percussive stunning" OR concussion OR concussive OR "concussive stunning" OR "concussive stun" OR stun OR stunning OR chilling OR bleeding OR bled OR electronarcosis OR electro-narcosis OR asphyxia OR asphyxiation OR exsanguination OR "carbon dioxide" OR evisceration OR eviscerate OR eviscerated OR decapitation OR decapitate OR decapitated OR spiking OR coring OR ike jime OR shooting OR shot)

For transport practices the following search query was used:

("Atlantic salmon" OR "Salmo salar" OR "common carp" OR "Cyprinus carpio" OR "rainbow trout" OR "Oncorhynchus mykiss" OR seabass OR "sea bass" OR "Dicentrarchus labrax" OR "sea bream" OR seabream OR "Sparus aurata") AND (welfare OR "well being" OR well-being OR wellbeing OR stress OR behaviour OR behavioural OR behavior OR behavioral OR physiology OR physiological OR osmolality OR cortisol OR cardiorespiratory OR "heart rate" OR "breathing rate" OR endocrine OR cope OR coping OR "coping style" OR "cardiac activity" OR ventilation OR "ventilation rate" OR mortality OR wound OR damage) AND (Transport OR transportation OR transports OR transportations OR transport-related OR transported OR transport-induced OR "fish transport" OR "transport fish" OR "fish transportation" OR "transportation fish" OR "fish transports" OR "transports fish" OR "transported fish" OR "fish transported" OR "transport-related fish" OR "fish transport-related" OR "fish transport-induced" OR "transport-induced fish" OR "fish transporting" OR "transporting fish" OR transporting)

For handling and equipment the following search query was used:

("Atlantic salmon" OR "Salmo salar" OR "common carp" OR "Cyprinus carpio" OR "rainbow trout" OR "Oncorhynchus mykiss" OR seabass OR "sea bass" OR "Dicentrarchus labrax" OR "sea bream" OR seabream OR "Sparus aurata") AND (welfare OR "well being" OR well-being OR wellbeing OR stress OR behaviour OR behavioural OR behavior OR behavioral OR physiology OR physiological OR osmolality OR cortisol OR cardiorespiratory OR "heart rate" OR "breathing rate" OR endocrine OR cope OR coping OR "coping style" OR "cardiac activity" OR ventilation OR "ventilation rate" OR mortality OR wound OR damage) AND (crowding OR crowded OR "crowding device" OR pump OR pumped OR pumping OR brailing OR brailed OR "brail net" OR brail OR net OR "dip net" OR netted OR loading OR load OR loaded OR unloading OR unloaded OR unload OR handling OR handled OR handle OR fasting OR fasted OR "feed withdrawal" OR "air lift" OR "transport vehicle" OR vehicle)

Websites

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