


Comparison of Norwegian health and welfare regulatory frameworks in salmon and chicken production

Kristine Gismervik¹ , Brit Tørud¹, Tore S. Kristiansen², Tonje Osmundsen³, Kristine Vedal Størkersen³, Christian Medaas⁴, Marianne Elisabeth Lien⁴ and Lars Helge Stien²

1 Norwegian Veterinary Institute, Oslo, Norway

2 Research Group Animal Welfare, Institute of Marine Research, Bergen, Norway

3 NTNU Social Research, Trondheim, Norway

4 Department of Social Anthropology, University of Oslo, Oslo, Norway

Correspondence

Kristine Gismervik, Norwegian Veterinary Institute, Pb 750 Sentrum, NO-0106 Oslo, Norway. Email: stine.gismervik@vetinst.no

Received 6 January 2020; accepted 30 April 2020.

Abstract

The health and welfare of farmed fish are often regarded with less concern than for other production animals. This review compares the Norwegian legal health and welfare frameworks for broiler chickens and farmed salmon, with the aim of improving regulations for salmon farming in Norway. Highlighting differences in laws, regulations and governmental organisation are also highly relevant in general, especially in developing welfare regulations for farmed fish in other countries. Norwegian chicken farmers must comply with two main laws, the Norwegian Animal Welfare Act and the Food Act, governed by the same ministry and governmental agency. The salmon farmers must in addition relate to the Aquaculture Act, different ministries and several agencies with different objectives. Compared to the regulation of chicken farming, the regulation of salmon farming is more complex, has potentially conflicting aims and uses less positive welfare phrasings. Thus, the regulation may be perceived as focusing on profitability over welfare. Despite having many similar paragraphs to regulation for chicken farming, salmon farming regulation is less strict in the daily securing of animals and recordings of mortality. There is no specified slaughterhouse control of high-density productions, as there is for broiler chickens. There are also differences in the mandatory welfare courses, one being that infection prevention is a stated topic for chickens. The Norwegian Animal Welfare Act has no possibility of dispensation, meaning exceptions, and treats fish and other animals equally. Future regulatory frameworks for farmed fish production should avoid unintended downgrading of fish health and welfare.

Key words: Animal welfare, farmed fish, governance, legislation, regulation, *Salmo salar*.

Introduction

Fish farming is an emerging animal industry affecting millions of individual fish, and still, fish are morally and legally treated with less concern for their health and welfare than other production animals (Lund *et al.* 2007; Rocklinsberg 2015). Norway has a general tradition of strong governmental control compared to many other countries (Christensen 2003). As a result, the national regulations and laws are often highly developed and complex, and the continual implementation of EU legislation adds further complexity. Concerning animal health, the Norwegian authorities have a tradition of combating rather than accepting animal

diseases (Thorud & Håstein 2003; NFSA 2018c). This has shown to be effective for terrestrial livestock, where in total only 74 outbreaks of serious infectious disease were reported in 2018 in Norway (NFSA 2018c). In comparison, a single virus disease, pancreas disease (PD), caused 163 new cases and infectious salmon anaemia virus, were reported to cause 13 outbreaks in Norwegian aquaculture in 2018 (Hjeltnes *et al.* 2019). The new EU Animal health directive (European Commission 2016) to be implemented in Norway in 2021 (NFSA 2019b), also focuses more on the prevention of animal disease but does not cover animal welfare, which the EU lacks a general law on. Still, on a national level, Norway's law on animal protection from

1974 included fish (Dyrevernlova, LOV-1974-12-20-73), and in January 2010, it was replaced by the Norwegian Animal Welfare Act (Dyrevelferdsloven, LOV-2009-06-19-97). In the legal scope of this act, all mammals, birds, reptiles, amphibians, fish, decapods, squid, octopi and honey bees are equally protected (Dyrevelferdsloven, LOV-2009-06-19-97). For Norway, the growing, economically important fish farming industry demands constant governmental developments in legal frameworks (Osmundsen *et al.* 2017). Concerning welfare, it is important to remember that this is something that is experienced by living individual animals (Noble *et al.* 2018; Hjeltnes *et al.* 2019). Norway produced 66 552 000 broiler chickens in 2018 (Landbruksdirektoratet 2019). In contrast, the number of fish in Norwegian aquaculture in 2018 was over 872 631 000. This number is made up of mainly Atlantic salmon (*Salmo salar*), but also rainbow trout (*Oncorhynchus mykiss*), fewer Atlantic cod (*Gadus morhua*), Atlantic halibut (*Hippoglossus hippoglossus*), turbot (*Psetta maxima*) and different so-called cleaner fish like lumpfish (*Cyclopterus lumpus*) used for salmon lice removal (Fiskeridirektoratet 2019a; Hjeltnes *et al.* 2019). Cleaner fish, being the upcoming second biggest production in Norway with its own health and welfare problems (Hjeltnes *et al.* 2019), are out of the scope of this review. This is partly due to biology and species-specific natural needs, exemplified by Jonsdottir *et al.* (2019) addressing the differences in salmon and lumpfish's ability to withstand water current speeds, highlighting that lumpfish need a more sheltered environment. Since national and EU regulations are developed and implemented at different times for various production animals, unintended discrepancies between different production animals may arise, such as salmon and broiler chickens. A specific trait for both production types is the high level of industrialised animal production and that each individual animal has low economic value. Since the Animal Welfare Act (Dyrevelferdsloven, LOV-2009-06-19-97) states the intrinsic value of animals independent of their utility to humans, the comparison of salmon and chicken regulatory frameworks can reveal the degree of implementation of this principle.

The Norwegian regulatory frameworks concerning health and welfare in salmon and broiler chicken production are reviewed here in order to highlight and learn from their differences. The aim was to find ways to improve the Norwegian health and welfare regulatory framework for farmed salmon.

The three animal production laws, governing ministries and supervising authority

There are two main laws regulating animal production in Norway: The Food Act (Matloven, LOV-2003-12-19-124) and the Animal Welfare Act (Dyrevelferdsloven, LOV-

2009-06-19-97). The Food Act's main aims are among others to secure safe food for the consumer, an environmentally friendly production and promote good animal health (Matloven, LOV-2003-12-19-124). This last point is, however, primarily applicable in the context of avoiding contagious diseases, and despite the close link between health and welfare, the term 'animal welfare' is not used in the law. At its implementation in 2003, the Food Act included a paragraph prohibiting production, processing, import or sale of foodstuffs produced in unacceptable ways concerning animal welfare, but this paragraph was removed with the implementation of the Animal Welfare Act in 2009 (Ot.prp.nr.100). The Animal Welfare Act promotes animal welfare, health and respect for animals. It states that animals have an intrinsic value independent of their utility to humans and that animals should be treated well and be protected from unnecessary stress and strains (Dyrevelferdsloven, LOV-2009-06-19-97). The Animal Welfare Act specifies everybody's responsibility for ensuring animal welfare, with a special focus on animal keepers. However, a specific statement giving the food processing industry overall responsibility for welfare-friendly products is lacking, beyond requirements on slaughtering procedures (Dyrevelferdsloven, LOV-2009-06-19-97). In comparison, the Food Act gives manufacturers overall responsibility for animal and plant health during the production cycle (Matloven, LOV-2003-12-19-124). This principle of whole chain thinking, also expressed as 'from the field and fjord to the table' (NFSA 2018c), is considered essential to achieve better health, both for the production animals themselves and us as consumers (Hofshagen & Kruse 2005; Desmarchelier *et al.* 2007). Another important difference is that the Food Act has a paragraph opening for the opportunity of dispensation to the law (Matloven, LOV-2003-12-19-124), while the Animal Welfare Act has no such paragraph (Dyrevelferdsloven, LOV-2009-06-19-97). In contrast to other animal productions, production of farmed fish also has its own designated law: the Aquaculture Act (Akvakulturloven, LOV-2005-06-17-79). The aim of this law is to promote the profitability of the aquaculture industry inside the limitations of sustainability. It does not have any direct references to animal health and welfare, except that farms can be ordered to move whether considerations for environment and fish health dictate this.

The Aquaculture Act is governed by the Norwegian Ministry of Trade, Industry and Fisheries (Nærings- og fiskeridepartementet, NFD), the Animal Welfare Act by the Ministry of Agriculture and Food (Landbruks- og matdepartementet, LMD), while the Food Act is governed by the Ministry of Health and Care Services (Helse- og omsorgsdepartementet, HOD), LMD and NFD (Fig. 1). LMD has responsibility for regulations in the Food Act related to terrestrial animals, NFD for aquatic production and HOD for

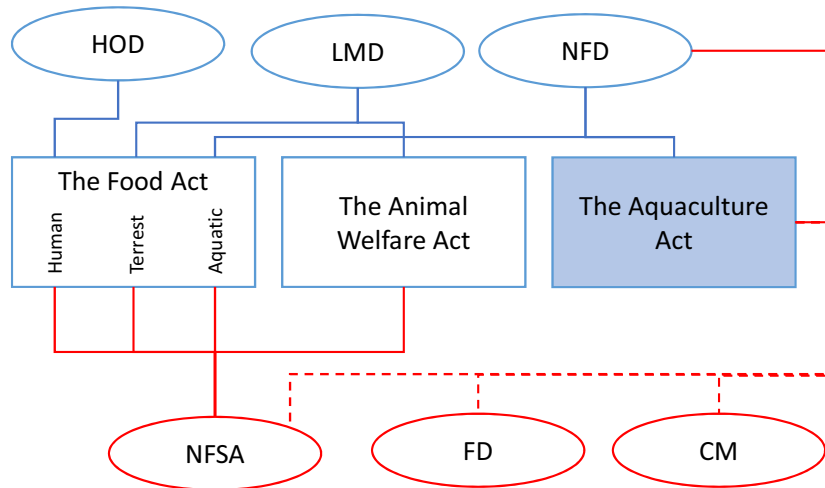


Figure 1 The main Norwegian ministries, laws and supervising authorities in production of animals in Norway. Blue line = governing ministry. Red line = supervising and enforcing authority, dashed = only when given authorisation by NFD through regulations. CM, county municipality [Fylkeskommunen]; FD, Directorate of Fisheries [Fiskeridirektoratet]; HOD, Ministry of Health and Care Services [Helse- og omsorgsdepartementet]; LMD, Ministry of Agriculture and Food [Landbruks- og matdepartementet]; NFD, Ministry of Trade, Industry and Fisheries [Nærings- og Fiskeridepartementet]; NFSA, Norwegian Food Safety Authority [Mattilsynet].

regulation related to human health after the primary production (i.e. farmer). Although the regulations emanating from the Food Act are made and regulated by the three ministries, the Norwegian Food Safety Authority (NFSA) has a role in supporting the ministries when making new regulations. If the regulation is of a technical and unpolitical nature, NFSA can on their own update or design new regulations to be approved by the relevant ministries. The Food Act (Matloven, LOV-2003-12-19-124) gives NFSA the responsibility of supervising producers' adherence to the law, as well as the power to enforce isolation, killing, destruction of animals or foodstuffs or require other special measures which might be considered necessary. NFSA also has the role of supervising and enforcing the Animal Welfare Act (Dyrevelferdsloven, LOV-2009-06-19-97). The Aquaculture Act is governed by NFD, but in contrast to the two other laws, NFD is responsible for appointing the surveillance and controlling agencies. However, it is typically stated for the regulation as a whole or specific paragraphs that NFSA, Directorate of Fisheries (Fiskeridirektoratet, FD) and/or the County Municipalities (CM) have supervising authority (Fig. 1). These authorities have different aims, which may influence how they manage their assigned regulations.

The NFSA's main aims are to promote (official translation): '(i) Safe, healthy food and water, (ii) Healthy plants, fish and animals, (iii) Ethical keeping of fish and animals, (iv) Environmentally friendly production, (v) Good quality, honest production and fair trade, and (vi) Innovation in the food sector' (NFSA 2019c). 'A society where food is safe and animal welfare safeguarded', cited as their vision in

their annual report of 2018 (NFSA 2018c). The FD's main aims are to (official translation); 'promote profitable economic activity through sustainable and user-oriented management of marine resources and the marine environment' (Fiskeridirektoratet 2019b). FD has also stated that their role is to be an efficient manager by implementing political decisions. The role of the NFSA is on the other hand to be independent, supplying the ministries and politicians with their professional competence and recommendations (Ot.prp.nr.100). It is worth noticing that the word 'dyr' [animals] from May 2019 is used as a general term covering both terrestrial animals and fish in Norwegian phrasings of the NFSA goals in their webpage (NFSA 2019d). That is 'fremme god dyrevelferd og respekt for dyr' [meaning: promote good animal welfare and respect for animals] (NFSA 2019d) in accordance with the Animal Welfare Act (Dyrevelferdsloven, LOV-2009-06-19-97). Moving away from the official translated English version of the aims which still divides [animals] into 'fish and animals' (NFSA 2019c), and thus give the impression that fish are not yet fully viewed as 'animals' (from latin 'animalis' – meaning having 'breath' or 'soul'). County municipalities are locally elected bodies with many public responsibilities. In this context, the most relevant is allocation of aquaculture licenses (new sites, size changes, etc.), which they decide after consulting other governmental bodies, that is FD, NFSA, Norwegian Coastal Administration [Kystverket], municipalities and County Governors [Fylkesmenn]. A County Governor is the state's representative in local counties, ensuring regional and national interests, that is recreation, nature conservation, fishing interests and discharges under the Pollution

Control Act, relevant for both aquaculture and poultry facilities (Fylkesmannen).

Key findings

Chicken farmers must comply with two laws governed by the same ministry, both of which are also managed by the same governmental agency. Salmon farmers must in addition also relate to a special law on aquaculture, two different ministries, and to several different agencies, which have potentially conflicting aims and roles. In addition, both chicken and aquaculture farmers must comply with the Pollution Control Act, and for aquaculture, the County Governor may have a more active role in, that is pollution from site or chemical use and measures after escapees, together with the FD.

Regulations for salmon and chicken production emanating from the three laws

We have identified altogether 36 regulations (Table 1) related to broiler chicken and/or salmon production having the legal basis in the Food Act (Matloven, LOV-2003-12-19-124), the Animal Welfare Act (Dyrevelferdsloven, LOV-2009-06-19-97) or the Aquaculture Act (Akvakulturloven, LOV-2005-06-17-79) (Fig. 2). In addition, the NFSA often enacts temporary local regulations to limit further spread of a disease (non-permanent regulations not included in Table 1). An example is if infectious salmon anaemia (ISA) is identified at a farm (e.g. regulations NFSA 2018a,b, 2019a). The legal basis of these regulations is the Food Act (Matloven, LOV-2003-12-19-124), and the regulations are typically only defined for a specific zone and for a limited time period, for example two years or until all the farmed salmon in the zone have been slaughtered and all the equipment is disinfected.

The regulation on combating salmon lice (regulation 5, Table 1) includes paragraphs on how to count the number of salmon lice and limits on the number of adult female lice per fish allowed. Although lice treatment is known to be one of the main challenges to fish welfare in aquaculture (Overton *et al.* 2018), the regulation itself is only based on the Food Act (Matloven, LOV-2003-12-19-124). The paragraph on evaluation of treatment (§9) focuses on the success of treatment and the avoidance of lice developing resistance to treatment, while fish welfare outcome is not mentioned.

The regulation on measures to prevent, limit and combat pancreas disease (PD), caused by salmon alphavirus (SAV) in aquaculture (regulation 6, Table 1), divides the country into different regional zones: an endemic zone (West Norway) where PD is tolerated and two monitoring zones (south and north of the PD-endemic zone) where occurrence of PD triggers control measures. These measures may

Table 1 Regulations related to salmon and chicken. Regulation identification number and long title translated from Norwegian[†]

#	ID	Long title of regulation (translated from Norwegian)
1	FOR-2003-12-19-1790	Government delegation according to the Food Act
2	FOR-2004-05-05-884	Delegation of authority to the NFSA following the Food Act
3	FOR-1997-02-20-192	Regulation on disinfection of intake water to and wastewater from aquaculture-related activities
4	FOR-2008-06-17-819	Regulation on the sale of aquaculture animals and products of aquaculture animals, prevention and control of infectious diseases in aquatic animals
5	FOR-2012-12-05-1140	Regulation on combating salmon lice in aquaculture plants
6	FOR-2019-06-25-920	Regulation on measures to prevent, limit and combat PD in aquaculture
7	FOR-2007-07-03-842	Regulations on combating avian influenza in poultry and other captive birds
8	FOR-2001-12-28-1616	Regulation on trade in live poultry and hatching eggs in the EEA
9	FOR-1994-11-18-1020	Regulation on the certification of poultry units
10	FOR-2006-03-09-297	Regulation on measures against bird flu
11	FOR-2015-06-18-761	Regulation on the use of animals in experiments
12	FOR-2004-02-13-406	Regulation on the payment of fees for special services from the NFSA
13	FOR-2008-12-22-1621	Regulation on official control of compliance with regulations on feed, foodstuffs and health and welfare of animals
14	FOR-2008-06-17-823	Regulation on the establishment and expansion of aquaculture facilities, zoo stores, etc.
15	FOR-2006-10-30-1250	Regulation on slaughterhouses and production facilities for aquaculture animals
16	FOR-2017-04-03-426	Regulation on fees for covering expenses related to supervision and control of fish health and fish welfare in aquaculture facilities
17	FOR-2006-07-03-885	Regulation on the welfare of production animals
18	FOR-2010-06-11-814	Delegation of authority to the Ministry of Agriculture and Food and the Ministry of Fisheries and Coastal Affairs under the Act on Animal Welfare
19	FOR-2014-06-30-925	Regulation on violation charges according to the Animal Welfare Act
20	FOR-2013-01-13-60	Regulation on the killing of animals

Table 1 (continued)

#	ID	Long title of regulation (translated from Norwegian)
21	FOR-2012-02-08-139	Regulation on commercial transport of animals
22	FOR-2001-12-12-1494	Regulation on the keeping of chickens and turkey
23	FOR-2001-12-21-1597	Regulation on fees and duties in connection with aquaculture activities
24	FOR-2004-12-22-1798	Regulation on permits for aquaculture for salmon, trout and rainbow trout
25	FOR-2005-12-28-1706	Regulation on the Aquaculture Register
26	FOR-2011-08-16-849	Regulation on requirements for technical standards for floating aquaculture facilities
27	FOR-2013-12-20-1675	Regulation on reactions, sanctions and more on violation of the Aquaculture Act
28	FOR-2015-02-05-89	Regulation on joint responsibility for recapture of escaped farmed fish
29	FOR-2009-06-22-961	Regulation on special requirements for aquaculture-related activities in or by national salmon rivers and national salmon fjords
30	FOR-2013-06-24-754	Regulation on the allocation of licenses for aquaculture with fish of salmon, trout and rainbow trout in seawater
31	FOR-2015-06-17-817	Regulation on the increase in maximum permissible biomass for salmon, trout and rainbow trout in aquaculture
32	FOR-2017-01-16-61	Regulation on production regions for aquaculture in the sea of salmon, trout and rainbow trout
33	FOR-2004-03-19-537	Regulation on internal control to fulfil aquaculture legislation
34	FOR-2008-06-17-820	Regulation on the transport of aquaculture animals
35	FOR-2008-06-17-822	Regulation on the operation of aquaculture facilities
36	FOR-2014-12-15-1831	Regulations on catch-based aquaculture

†Non-permanent regulations for combating diseases and special regulations for ecological or green farming are not included. Regulations available at www.lovdata.no

include testing of neighbouring farms, fish movement restrictions and emergency slaughter. In addition, the PD-endemic zone is divided into a SAV3 and a SAV2 zone. When SAV3 is detected in the SAV2 zone, eradication is the measure most often used. SAV2 detection in the SAV3 zone is not always treated so rigorously. The practice of tolerating a disease like PD in the PD-endemic zone has a

severe negative impact on the fish welfare (Noble *et al.* 2018; Hjeltnes *et al.* 2019) and therefore also means accepting different welfare conditions in different parts of Norway. Notice also that the PD regulation is only based on the Food Act (Matloven, LOV-2003-12-19-124) and does not have any paragraphs with legal basis from the Animal Welfare Act (Dyrevelferdsloven, LOV-2009-06-19-97).

For chickens, there are permanent regulations on combating avian influenza (regulations 7 and 10, Table 1). In short, the first regulation states that on suspicion of avian influenza, production must be quarantined. On confirmation, all animals are euthanised, and contagious material is destroyed including total disinfection procedures. The second regulation involves special restrictions to prevent infection of farmed chickens in the case of suspected avian influenza in nearby wild bird populations. This focus on avoiding the spread of disease is also true for the sales regulations for both species (regulations 4 and 8, Table 1) and the special regulations to avoid introduction of pathogens (regulations 3, 4 and 8, Table 1). The two other regulations based on the Food Act (regulations 1 and 2, Table 1) relate to government delegation of authority.

The regulations with legal basis in both the Food Act and the Animal Welfare Act (regulations 11–17, Table 1, Fig. 2) primarily deal with NFSA's fees and activity (regulations 12, 13 and 16), animals in experiments (regulation 11, Table 1), the establishment of new aquaculture facilities (regulation 14, Table 1) and slaughterhouses for aquaculture animals (regulation 15, Table 1). These regulations have only an indirect effect on the day-to-day salmon or chicken production. This is also true for most of the regulation based on the Animal Welfare Act alone (regulations 18–22, Table 1, Fig. 2). The exceptions are the regulation for the killing of animals (regulation 20, Table 1), the regulation for the commercial transport of animals (regulation 21, Table 1) and the two regulations for the keeping of animals pertaining to broiler chickens (regulations 17 and 22, Table 1, Fig. 2). Although salmon is under the regulation for commercial transport, there is a specific regulation for transport of aquaculture animals (regulation 34, Table 1) with all three laws as the legal basis (Fig. 2). Similarly, there is a special paragraph on the killing of fish in the operation of aquaculture facilities regulations (regulation 35, Table 1, Fig. 2). Notice also that the general regulation concerning welfare of production animals does not apply to fish (regulation 17, Fig. 2), as this regulation is based on EU directive 98/58/EF, mostly focusing on land-based production (European Commission 1998).

The 14 regulations with the Aquaculture Act as legal basis (Fig. 2) all affect salmon farming, in addition to seven regulations specific for fish under the two other laws (Fig. 2), illustrating the complexity of the fish farming regulations. There are eight regulations that comply to both salmon and chicken, but only six specific to chicken or poultry. Most of

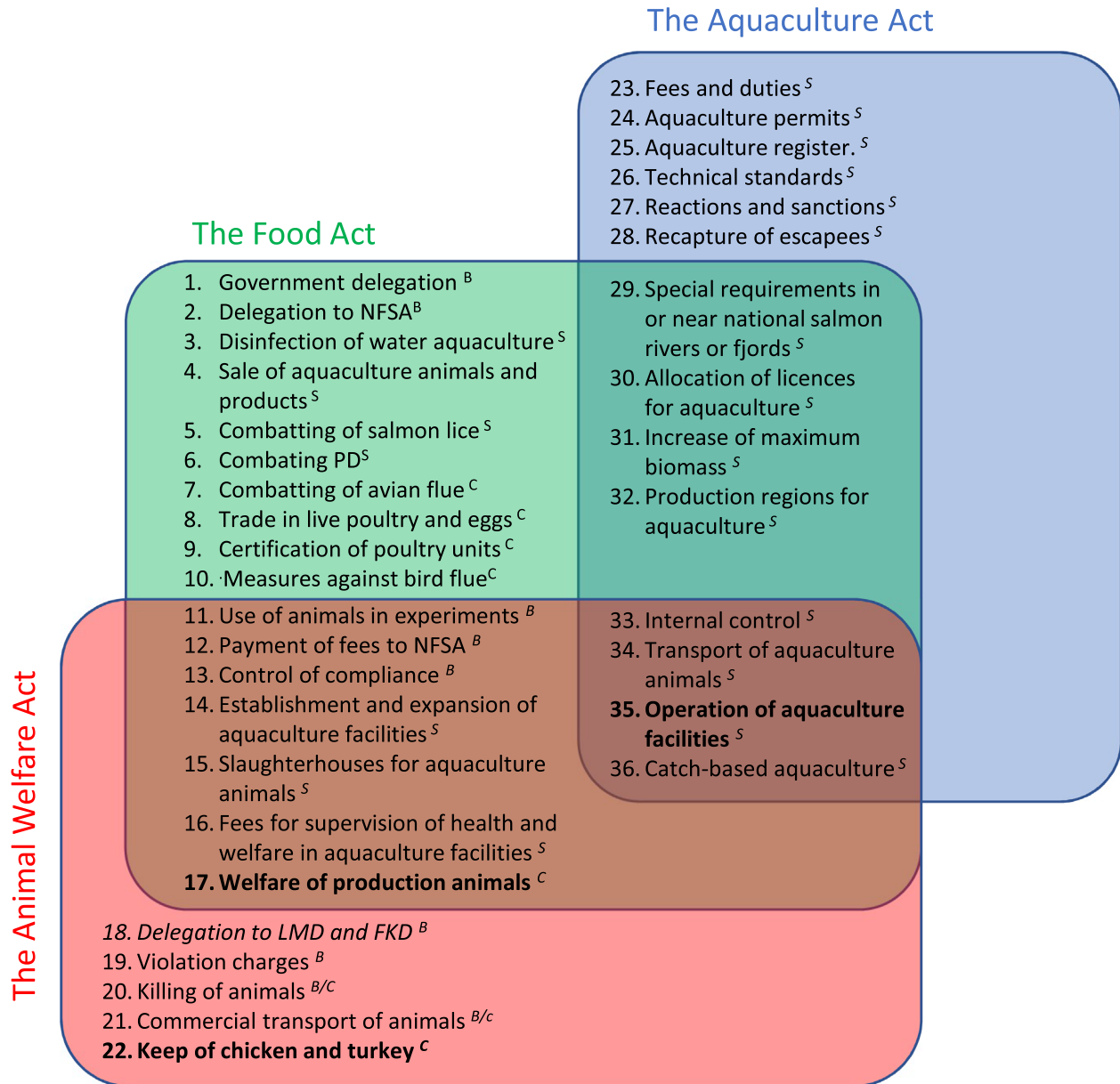


Figure 2 Norwegian regulations in salmon and broiler chicken production in relation to which of the three laws they have as legal basis. Red box = the Animal Welfare Act, green box = the Food Act and blue box = the Aquaculture Act. The regulation names given in the figure are shortened from Table 1. B = Regulation applies for both broiler chicken and salmon, C = only broiler chicken, S = only salmon, B/C = both, but predominantly broiler chicken production.

the regulations with the Aquaculture Act as legal basis do not, however, directly interfere with the daily running of farms. This part is cumulated into the regulations on the operation of aquaculture facilities (regulation 35, Table 1). In addition, there is a special regulation to ensure that there are internal control systems for checking that aquaculture regulations are upheld at the farms (regulation 33, Table 1). The closest analogue to regulations for keeping farmed fish (regulation 35, Table 1) deals with all aspects of fish farming

and has all three laws as legal basis. The regulation for keeping chicken (regulation 22, Table 1) on the other hand primarily deals with health and welfare, and is therefore only based on the Animal Welfare Act (Fig. 2).

Key findings

Regulations concerning combating disease are based on the Food Act; consequently, welfare is not specified. Where

there are general regulations for animals, there is usually a special regulation for fish. There are three 'keeping of animals' regulations: a general one that does not apply to fish, a special one for chicken and turkey, and a special one for farmed fish. There are substantially more regulations for salmon than for chicken.

Animal welfare as defined by the Animal Welfare Act

None of the laws or regulations in Table 1 contain a definition of animal welfare or what constitutes good animal welfare. According to the preparatory documents to the Animal Welfare Act (Ot.prp. nr. 15), this is partly due to the history of scientists using different definitions (Fig. 3) and that the concept of good welfare changes with time (Fraser *et al.* 1997; Mellor *et al.* 2009; Mellor 2016). Most famous are 'the five freedoms', the principles for good welfare made by the UK Farm Animal Welfare Council: (i) Freedom from hunger, thirst and malnutrition, (ii) Freedom from discomfort, (iii) Freedom from pain, injury or disease, (iv) Freedom to express normal behaviour, and (v) Freedom from fear and distress (FAWC 1993; Mellor 2016). The Animal Welfare Act demands that keepers of animals must ensure adequate food and water (§24), protect against unnecessary discomfort (§3), protect against harm and disease (§24), ensure possibility for natural behaviour (§23) and protect the animals from unnecessary stress (§3) (Dyrevelferdsloven, LOV-2009-06-19-97). The Welfare Act therefore seems to have included the five-freedom principles, but it also seems to include the newer welfare needs concept adopted by many welfare scientists, including FAWC (e.g. Bracke *et al.* 1999; FAWC 2012; Mellor *et al.* 2009; Stien *et al.* 2013; Noble *et al.* 2018). Here, the fulfilment of an animal's nutritional needs, environmental needs, health needs and behavioural needs generates feelings, where the positive or negative sum of these feelings comprises an animal's welfare status. In other words, animal welfare is the quality of life as perceived by the animal itself (Bracke *et al.* 1999; Stien *et al.* 2013). The Animal Welfare Act clearly states that good animal welfare means that the animals are healthy and have no injury or disease, are properly bred (§§3, 22, 24, 25), have their environmental (§§8 and 23) and nutritional needs (§24) met, have their behavioural needs (§23) met and feel safe and have a state of wellbeing (§§3 and 23) (Dyrevelferdsloven, LOV-2009-06-19-97).

Key finding

Although there is no clearly stated definition in the Animal Welfare Act, it clearly includes common animal welfare concepts, and the view that animal welfare is the quality of life as perceived by the animal itself.

Comparison of welfare needs given in regulations for keeping animals

There are regulations detailing how specific species of production animals can be kept and treated in Norway. For chickens, the regulation on the keeping of chicken and turkey (regulation 22, Table 1), and for salmon, the regulation on the operation of aquaculture facilities (regulation 35, Table 1) are central and will here be compared. As previously stated, both have the Animal Welfare Act (Dyrevelferdsloven, LOV-2009-06-19-97) as part of their legal basis (Fig. 2). Consequently, many paragraphs of both regulations are similar when it comes to promoting general animal welfare and the environmental, as well as nutritional and behavioural needs of the animals (not commented further). However, the operation of aquaculture facilities regulation is also based on the Food Act (Matloven, LOV-2003-12-19-124) and the Aquaculture Act (Akvakulturloven, LOV-2005-06-17-79), making it more comprehensive. The mission statement, central in understanding the purpose of a regulation, reflects this (see details in Table 2). The first part of the mission statement is directly reused from the Aquaculture Act and puts profitability first. For comparison, there is no analogous law or regulation promoting profitability for the chicken industry. The second part adds an 'also' concerning good health and welfare for fish. Although in legal terms, the order of aims or objectives in a mission statement is said to be unimportant, we hypothesise that on a psychological level, the ordering may give many the impression that health and welfare for fish is secondary. This would be a misinterpretation, as the Animal Welfare Act has no possibility of dispensation, meaning the provision of exceptions from the law (Dyrevelferdsloven, LOV-2009-06-19-97). The regulation of chickens specifies in the mission statement to 'ensure that the natural needs of the animals are taken into account', a goal not stated for salmon (Table 2).

Key findings

Many of the rules in the regulations for keeping chicken and salmon are analogous. However, the regulation on the operation of aquaculture facilities is more complex, mainly due to the implementation of rules from three laws, compared to one for chicken. The regulation for keeping salmon may be perceived as focusing on profitability more than welfare.

Phrasings concerning wellbeing and feeling safe

The way in which things are said or phrased matters, as it may affect our attitudes to and understanding of the welfare concept (Vigors 2019). Although many rules in the two regulations for keeping salmon and chicken are analogous,

What is animal welfare?

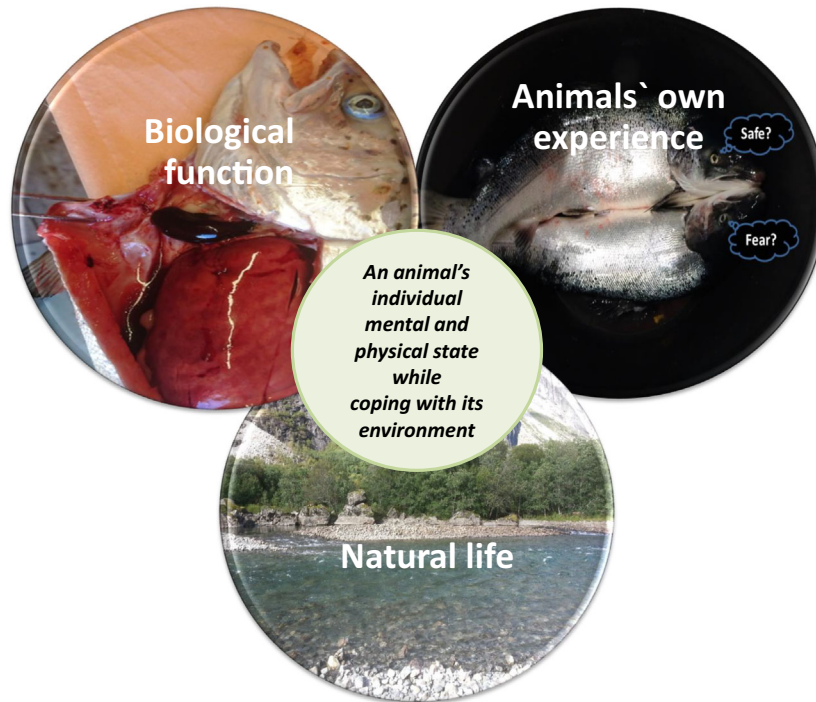


Figure 3 Three common dimensions of the term animal welfare are (i) biological function, with good health and normal development, (ii) the animals' own experience with regard to feelings such as fear and pain and (iii) a natural life (as far as is possible) including a natural environment. One way of defining welfare which takes these different views into consideration could be; 'An animals' individual mental and physical state while coping with its environment' (adjusted from Broom 1986). Illustration: K. Gismervik, photos: Norwegian Veterinary Institute.

some of the more positive phrasings concerning welfare needs from the Animal Welfare Act (Dyrevelferdsloven, LOV-2009-06-19-97) are reused in the regulation for chicken, but are lacking in the regulation for salmon, for instance, 'wellbeing' and 'psychological needs'. The regulation for the operation of aquaculture facilities uses the terms 'acceptable welfare and health' (§5) and 'unnecessary strains' (§§19, 28, 29), phrases that seem less welfare-charged. In general, chickens should be 'protected from unnecessary stress, pain and suffering' (§4), the 'floor, perches and other materials should not cause discomfort to the animals' (§7) and the handling should not cause unnecessary fear (§19). Both regulations state that the animals should be protected against injuries. Still, phrases like 'protection against avoidable pain, suffering and fear' are in the regulation for the operation of aquaculture facility only used in conjunction with the killing of fish (§34). This originates from Council regulation (EC) No 1099/2009 that includes fish, despite to a lesser extent, in protection of animals when killed (European Commission 2009). Differences in phrasings could also have the effect of drawing the attention to welfare as an aspect most relevant to slaughter of fish, rather than to the production life cycle as a whole,

which is where the animals spend most of their time. Both the chicken and salmon regulations are in the phrasings focusing more on 'avoiding negatives' than 'adding positive' welfare experiences. Lawrence *et al.* (2019) reviews that focusing on a more positive animal welfare can bring in a full life perspective including happiness and quality of life.

Key findings

The Animal Welfare Act has the same phrasings and regulations for all of the species it covers, including salmon. However, in the regulation for keeping chickens, there is more use of positive and welfare – charged terms such as wellbeing and psychological needs, and more attention drawn to the chickens' entire life cycle. Both regulations are focusing more on 'avoiding negatives' than 'adding positive' welfare experiences.

Competence and care

To ensure optimal treatment and care of farmed chickens and salmon, there are paragraphs on adequate competence and training and the presence of personnel to secure the animals on a daily basis. Welfare courses became

Table 2 Mission statements (§1) in regulations for keeping farmed salmon and broiler chickens compared to mission statements in the Norwegian Animal Welfare Act (red text), the Food Act (green text) and the Aquaculture Act (blue text), (translated by the authors from Norwegian). Notice that the general regulation for keeping of production animals does not apply to farmed fish, and that the regulation on keeping of chickens and turkey is based solely on the Animal Welfare Act.

		Regulations for keeping		Salmon
		Broiler chickens		
The Animal Welfare Act (LOV-2009-06-19-97)	The Food Act (LOV-2003-12-19-174)	The Aquaculture Act (LOV-2005-06-17-79)		
§1. The intention of this Act is to promote good animal welfare and respect for animals'	§1. The intention of this Act is to ensure safe and wholesome food, to promote health, quality and consumer concerns along the entire production chain, and to provide for sustainable production. The law shall further promote good plant and animal health. The Act will also take into account the interests of operators throughout the production chain, including market access abroad'	§1. The Act will promote the profitability and competitiveness of aquaculture industry within the framework of sustainable development and contribute to wealth creation on the coast'	§1. The regulation will contribute to good health and wellbeing for production animals'	§1. The regulation will promote the profitability and competitiveness of aquaculture industry within the framework of sustainable development and contribute to wealth creation on the coast. The aim is also to promote good health in aquaculture animals and to ensure good welfare in fish'

mandatory for Norwegian salmon producers (§6) in 2010 and for chicken producers (§5) in 2013. The content and approval of such courses are described in the regulations, focusing on the animal's normal physiology, environmental and psychological needs including behaviour and stress at different productions and life stages, and the welfare concept and regulations. Since 19 April 2018, welfare courses for salmon producers no longer need approval from NFSA, while chicken courses do. Still, the main topics are specified in the salmon regulation and that the welfare course provider must be an expert in the field, that is a veterinarian or fish health personnel (§6). But, it is not stated specifically that preventive health work or infection prevention is the topic to be covered, as it is for chicken producers. The need for competence when considering infection prevention is, however, according to §8 in the Food Act, a demand also for salmon producers (Matloven, LOV-2003-12-19-124). Salmon producers are obligated to repeat the welfare course when needed, and at least every 5th year (§6). Such regular competence updates are not required of chicken producers. For salmon, 'there should be enough personnel with fish welfare competence' (§6). Still, the welfare courses have mainly been directed towards the operators and site manager working with the fish, but not the higher-level leaders who make economic and organisational decisions that affect production and thus welfare.

When it comes to securing the animals on a daily basis, each chicken needs to be attended and observed as often as needed, and at least twice a day (§16). Automatically monitoring equipment cannot replace physical presence of personnel (§16), and sick chickens should be treated or euthanised immediately (§18). Although there are many more individuals in each site for farmed salmon compared to chickens, the salmon should be checked 'at least once a day if weather permits' (§12). To watch 'all animals' is not specified, nevertheless, §19 states that it should be easy to inspect the fish in the production unit (i.e. cage or other installations), and §34 that salmon if necessary should be euthanised as 'soon as possible'. The Animal Welfare Act states that technical solutions should be suitable for safeguarding the welfare of the animals (§8) and that the animals' environments should promote good health, safety and wellbeing (§23). In aquaculture, the increasing sizes of cages or containers holding up to 200 000 individual fish, make it hard to comply with easy inspection and good treatment, and the trend of emerging technologies facilitating even more individuals raises concerns. Regular rounds such as checking the fish' behaviour and appetite are used as an indication, but are not always sufficient to detect disease (Lien 2015; Noble *et al.* 2018). Systems of taking out moribund and emaciated fish with highly reduced welfare, or fish to be treated differently, are often lacking (Noble *et al.* 2018). It may also be challenging to quickly remove

dead animals, which is important both from a biosecurity (Aunsmo *et al.* 2008; Ellis *et al.* 2012) and an ethical point of view. For both salmon and chicken production, dead animals should be registered and removed on a daily basis, but for chickens, the cause of death or euthanasia should if possible also be stated (§35c). Such practices can help to determine health and welfare problems, and also reduce them, for instance by the early detection of infectious diseases (Aunsmo *et al.* 2008; Hjeltnes *et al.* 2018). In the regulation for chickens, a clear definition of mortality, including chickens euthanised due to disease or other causes, is stated. For salmon, this is not stated specifically. Lack of definitions may lead to differences in how the mortality numbers are reported and categorised in salmon, as reporting of losses to the government also covers 'destruction' and 'other losses', in addition to 'mortality' (Hjeltnes *et al.* 2019). For salmon, it is stated that 'increased mortality' is to be reported to the government (§14), yet it is only defined as 'significantly more than normal' (§4j), from 2018 excluding in the regulation text that this is 'something to be determined together with the NFSA'.

Key findings

Regulatory differences concerning welfare courses include the need of approval of the welfare course for chickens, but not for salmon. Salmon producers must repeat the course when needed, at least every 5th year, which is not specified for chicken producers. None of the regulations specify that high-level company leaders should have welfare courses. It is not stated specifically that preventive health work or infection prevention is the topic to be covered for salmon producers, as is the case for the welfare courses for chicken. Based on §8 in the Food Act, salmon farmers still need competence in infection prevention.

Compared to chickens, salmon are regulated less strictly regarding securing the animals on a daily basis and recording of mortality

Slaughterhouse control of high-density productions

When producing more than 200 chickens with a higher animal density than 33 kg m^{-2} , it is mandatory to control the number of reported mortalities up against the actual number of slaughtered animals in the slaughterhouse. It is stated that the actual planned numbers must be reported to the NFSA, still never more than the maximum stocking density of 36 kg m^{-2} , and that documentation of the buildings and technical equipment must be available. There are specific regulations on environmental conditions like amount of NH_3 , CO_2 , temperature and humidity. Producers that have more than the standard chicken density of 25 kg m^{-2} must be enrolled in an animal welfare program acknowledged by the NFSA. Such programs contain, among other things, a

foot-pad dermatitis scoring system implemented at slaughter, affecting the density allowed in the next production (§35 b). NFSA is in the slaughterhouse on a daily basis, controlling among other things the welfare of the chickens. In comparison, for salmon there is no daily governmental slaughterhouse control, no governmental rules of animal welfare programs or use of specified welfare indicators, no specific environmental standards for animal density above 25 kg m⁻³ permitted for closed cages and slaughter cages since 2018 (§25), and no given upper animal density for juveniles (pre-smolts). A full comparison of the rules for slaughterhouses for broiler chickens and salmon is out of scope of this review, but salmon do have detailed welfare rules given in the regulation on slaughterhouses and production facilities for aquaculture animals (regulation 15, Table 1, Fig. 2). Among others, farmed salmon must be unconscious during exsanguination and remain unconscious until death.

Key findings

There is no paragraph for attending an animal welfare program, which can specify what welfare is, in the regulation for salmon. Slaughterhouse control is more developed for chickens than for salmon production; for chicken, there are also more specific regulations aimed at animal welfare for high-density productions.

Proper breeding, light and noise conditions

For chickens, it is stated that the breeding program should focus on healthy and robust animals, selecting away specific negative characteristics like poor health including leg problems, aggression, fear, feather pecking and need of restrictive feeding (§24). They should tolerate normal light conditions and circadian rhythms (§24). Concerning environmental light conditions, specific rules are detail that light should be adapted to the animal's natural circadian rhythm. A minimum of 6 h darkness period per night, or two periods lasting at least 4 h, and rules of light intensity during daytime are stated (§35). The noise level should be as low as possible (§13). For salmon, the same focus of healthy and robust fish in the breeding program is stated, as well as domestication (§51). Still, compared to chickens, characteristics are less defined, but the statement that 'no fish should be held in farms unless the genotype or phenotype indicates that it is possible to maintain good welfare and health' can be interpreted as a strict framework. One problem, however, can be the consensus of defining 'good welfare and health'. There is no specific rule detailing light or noise conditions for salmon, although correct light conditions are important for smoltification (Stefansson *et al.* 2007; Noble *et al.* 2018). Constant light is found to have negative effects in neurological development of parr

(Ebbesson *et al.* 2007). Ebbesson *et al.* (2007) reported that constant light inhibited optic nerve fibre growth into hypothalamus, disturbing parr-smolt transformation, and there might be a knowledge gap concerning constant light and negative welfare effects (Noble *et al.* 2018). Uneven light and shadow conditions can increase eye snapping, meaning fish attacking the eyes of conspecifics (Noble *et al.* 2012). Sudden changes in light conditions, that is light from darkness or opposite, may cause stress and panic reactions (Mork & Gulbrandsen 1994). Sounds can have aversive effects on fish, especially low-frequency sounds (Bui *et al.* 2013).

Key findings

There are rules of health and robustness in breeding programs for both salmon and chickens; however, for salmon, the characteristics are less defined rendering it more challenging to define genotypes or phenotypes that promote good welfare. For salmon, there are no specific rules regarding light or noise conditions, although it likely affects them.

Recommendations of regulation development based on the key findings

The Animal Welfare Act (Dyrevelferdsloven, LOV-2009-06-19-97) gives no opportunity for dispensation or exception from the law, like you find in the Food Act (Matloven, LOV-2003-12-19-124). There is no difference between the importance of health and welfare of chicken and the health and welfare of salmon in the law. From this, it follows that the health and welfare for broiler chicken production and for salmon production should be promoted equally in the regulations that are authorised by the Animal Welfare Act. NFSA is the formal authority of governmental control and competence of animal welfare and health. It is therefore important that they are represented in matters or processes where decisions or early impact can easily be made. This is especially important when decisions influence infection prevention or pressure and the welfare of fish, as relevant for, that is industry growth and infrastructure and development of technologies. To integrate more of the welfare aspects also in the health regulations might help to prohibit unintentional downplaying of the welfare focus for fish, exemplified by the salmon lice regulation lacking a focus on fish welfare outcomes. Tønnessen (2018), reviewing the Norwegian political programs from 2013 to 2017, found that animals and animal welfare in general was given very little attention. 'Fish', the most frequently mentioned animal, was almost exclusively referred to in terms of economic resources rather than as sentient beings (Tønnessen 2018). Hence, for salmon, it may be even more important than for other production animals to build regulations and

governmental agency structures that take animal welfare and health into account and ensure the priority of welfare.

Farmed fish are unique among production animals in Norway, in that they have a designated law, the Aquaculture Act (Akvakulturloven, LOV-2005-06-17-79), for promoting the economy of the industry. This may create unintended differences between farmed fish and other production animals when it comes to animal welfare. However, the Aquaculture Act does also aim at 'sustainable development'. To consciously incorporate and describe fish health and fish welfare into the poorly defined concept of sustainability (Janoušková *et al.* 2019) can be one way of contributing to changes in mindset. Aquaculture has a complex regulation, in that the farmers have to relate to several different governmental agencies with potentially conflicting objectives. In addition, the regulation for keeping salmon is authorised from three laws, which also have potentially conflicting objectives. If the health and welfare of the fish have precedence, this should be stated clearly in the mission statement of the regulation for keeping salmon, as it is in the mission statement in the regulation for keeping chicken, to avoid ambiguity. The lack of 'positive phrasings' in the salmon regulation concerning welfare should be addressed, as this may affect attitudes. To avoid unintended differences, future regulations of any production animals, including fish, should underline the importance of care and wellbeing in the whole production cycle. The Animal Welfare Act (Dyrevelferdsloven, LOV-2009-06-19-97) applies a common animal welfare concept. Still, there might be a need for more defined guidelines or consensus to understand and govern what can be defined as good welfare and health – and this should take into account that what can be accepted will change along with development of knowledge or production systems. One way of solving this can be to further develop Animal Welfare programs, and look more thoroughly into what details should be in the regulations and what should be a reference to industry standards or similar.

Areas of standardisation between the regulations for keeping salmon and broiler chickens can be welfare courses, securing animals on a daily basis including mortality numbers, causes and definitions, slaughterhouse controls, requirements of animal welfare programs in regulation and regulations of light and sound conditions. A key difference between Norwegian broiler chicken farms and salmon farms is that the personnel doing the day-to-day safeguarding of the broiler chicken usually own the farm and make long-term decisions themselves. Salmon farming, on the other hand, is dominated by large companies with several levels of management, where the long-term decisions regarding infrastructure and farming strategies are made centrally. This highlights that in addition to the personnel

doing the day-to-day safeguarding on the fish farm, high-level company leaders and administrative staff should have knowledge of fish health and welfare, for instance through welfare courses. According to §8 in the Food Act (Matloven, LOV-2003-12-19-124), competence in infection prevention is mandatory, and welfare courses for salmon producers might as well as specified for broiler chicken producers, be an arena for updating such knowledge. The introduction of more specific slaughterhouse control of salmon should also be considered, as is the case for broiler chicken. Future regulatory frameworks for farmed fish production should avoid unintended downgrading of the fish health and welfare, including the enforcement of the regulations not covered further in this review.

Implications for future international regulations

International animal welfare and health regulations can help the countries to develop a high standard of how we treat animals and work with preventive health care. Still, laws and regulations need to be written in a way that people can relate to and understand. In Norway, it is a new trend that EC regulations are implemented by a short regulation referring to the original, rather voluminous, text, making it sometimes difficult to understand. When it comes to national laws, Norwegian salmon have the same protection in the Animal Welfare Act as other production animals (Dyrevelferdsloven, LOV-2009-06-19-97). However, this law is only 10 years old. Our tradition of harvesting from the sea and the lack of knowledge of fish welfare needs and how to measure welfare in farmed fish have delayed looking at fish as sentient beings, in Norway and elsewhere (Seibel *et al.* 2020). Still, Norway is in front working with fish welfare issues, exemplified by the many welfare rules for farmed salmon, development of welfare assessment methods and literature reviews (Stien *et al.* 2013; Noble *et al.* 2018). People's attitude towards fish, and the organisation of animal welfare with different governmental agencies and other laws can give rise to unintended differential treatment between animal classes. When it comes to fish, it is also important to remember that fish is a collective term; different fish species will have different needs. Making new regulations are challenging. Based on findings in this paper, we have summarised some general recommendations concerning welfare and health regulations for farmed fish: (i) Provide clear aims in the regulations with positive phrasings to give the expectations that fish have the same animal welfare protection as other farm animals; (ii) include whole chain thinking, adding both animal welfare and health, infection prevention and environmental concerns where proper. (iii) The regulations should give an idea or definition of what animal welfare is for the specific species based on their welfare needs. One solution is to make it mandatory in the

regulations to attend animal welfare programs, where details can be more specified compared to a general legal text. Other solutions are rules for written routines, surveillance programs and regular slaughterhouse controls supervised by fish health professionals or similar. (iv) The regulations should place the responsibility for animal welfare and state the needed competence/courses, including updates, with focus on both animal caretakers and company leaders, in addition to the mandatory role and visits by veterinarians or fish health personnel. (v) Regulations should focus on individual caretaking of the fish in the whole production cycle, not only at the time of slaughter. This also includes regulations for daily removal of moribund and dead fish with the aim of determining the reasons they died, so both the industry and the government know what mitigating measures to make. (vi) There should be regulations for documenting that the technology and methods in use are fish welfare friendly as well as good emergency plans to ensure fish welfare based on risk assessments. (vii) To ensure compliance with regulations, governmental control points, including sanctions, should be established. The producers should have to document and report measures of fish welfare and health as a basis for licences, increases or changes in productions, localisation, etc.

To make such regulations, it is a prerequisite that governmental agencies and policy-makers take animal welfare and health into consideration in future development and improvement of the regulatory framework for farmed fish.

Acknowledgements

This research was funded by the Research Council of Norway Project 267664 REGFISHWELH. We would also like to thank Steinar Johnsen at the Norwegian Food Safety Authority for his expert advice in interpreting the regulatory framework. Thanks to Claire Peterson for proof reading.

Conflicts of interest

The authors declare no conflict of interest.

References

- Akvakulturloven (LOV-2005-06-17-79) The Norwegian Aquaculture Act. Akvakulturloven LOV-2005-06-17-79. Norwegian Ministry of Trade, Industry and Fisheries. [Cited 1 November 2019.] Available from URL: www.lovdata.no
- Aunsmo A, Bruheim T, Sandberg M, Skjerve E, Romstad S, Larsen RB (2008) Methods for investigating patterns of mortality and quantifying cause-specific mortality in sea-farmed Atlantic salmon *Salmo salar*. *Diseases of Aquatic Organisms* **81**: 99–107.
- Bracke MBM, Spruijt BM, Metz JHM (1999) Overall animal welfare reviewed. Part 3: welfare assessment based on needs and supported by expert opinion. *Netherlands Journal of Agricultural Science* **47**: 307–322.
- Broom DM (1986) Indicators of poor welfare. *British Veterinary Journal* **142**: 524–526.
- Bui S, Oppedal F, Korsoen OJ, Sonny D, Dempster T (2013) Group behavioural responses of Atlantic salmon (*Salmo salar* L.) to light, infrasound and sound stimuli. *PLoS ONE* **8**: e63696.
- Christensen T (2003) Narratives of Norwegian governance: elaborating the strong state tradition. *Public Administration* **81**: 163–190.
- Desmarchelier P, Fegan N, Smale N, Small A (2007) Managing safety and quality through the red meat chain. *Meat Science* **77**: 28–35.
- Dyrevelferdsloven (LOV-2009-06-19-97) The Norwegian Animal Welfare Act. Dyrevelferdsloven LOV-2009-06-19-97. Norwegian Ministry of Agriculture and Food. [Cited 1 November 2019.] Available from URL: www.lovdata.no
- Dyrevernlova (LOV-1974-12-20-73) The Norwegian Animal Protection Act. Dyrevernlova, LOV-1974-12-20-73. Norwegian Ministry of Agriculture and Food, Oslo.
- Ebbesson LOE, Ebbesson SOE, Nilsen TO, Stefansson SO, Holmqvist B (2007) Exposure to continuous light disrupts retinal innervation of the preoptic nucleus during parr-smolt transformation in Atlantic salmon. *Aquaculture* **273**: 345–349.
- Ellis T, Berrill I, Lines J, Turnbull JF, Knowles TG (2012) Mortality and fish welfare. *Fish Physiology and Biochemistry* **38**: 189–199.
- European Commission (1998) Council Directive 98/58/EC of 20 July 1998 concerning the protection of animals kept for farming purposes. [Cited 4 September 2019.] Available from URL: <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A31998L0058>
- European Commission (2009) Council Regulation (EC) No 1099/2009 of 24 September 2009 on the protection of animals at the time of killing. [Cited 22 November 2019.] Available from URL: <https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:303:0001:0030:EN:PDF>
- European Commission (2016) Regulation (EU) 2016/429 of the European Parliament and of the Council of 9 March 2016 on transmissible animal diseases and amending and repealing certain acts in the area of animal health ('Animal Health Law').
- FAWC (1993) *Farm Animal Welfare Council (FAWC) second report on priorities for research and development in farm animal welfare*. DEFRA, London.
- FAWC (2012) Farm Animal Welfare Council webpage, Five Freedoms archived 10.10.12. [Cited 23 April 2020.] Available from URL: <https://webarchive.nationalarchives.gov.uk/20121010012427/http://www.fawc.org.uk/freedoms.htm>
- Fiskeridirektoratet (2019a) Directorate of Fisheries. [Cited 31 October 2019.] Available from URL: <https://www.fiskeridir.no/Tall-og-analyse>

- Fiskeridirektoratet (2019b) Directorate of Fisheries. [Cited 11 October 2019.] Available from URL: <https://www.fiskeridir.no/English/About-the-directorate/Vision-goal-and-role> accessed
- Fraser D, Weary DM, Pajor EA, Milligan BN (1997) A scientific conception of animal welfare that reflects ethical concerns. *Animal Welfare* **6**: 187–205.
- Fylkesmannen County Governor. [Cited 1 November 2019.] Available from URL: <https://www.fylkesmannen.no/>
- Hjeltnes B, Bang-Jensen B, Bornø G, Haukaas A, Walde CSE (2018) The health situation in Norwegian aquaculture 2017. In: *Norwegian Veterinary Institute Report No. 1b–2018*, pp. 108. Norwegian Veterinary Institute, Oslo.
- Hjeltnes B, Bang-Jensen B, Bornø G, Haukaas A, Walde CSE (2019) The health situation in Norwegian aquaculture 2018. In: *Norwegian Veterinary Institute Report No. 6b–2019*, pp. 132. Norwegian Veterinary Institute, Oslo.
- Hofshagen M, Kruse H (2005) Reduction in flock prevalence of *Campylobacter* spp. in broilers in Norway after implementation of an action plan. *Journal of Food Protection* **68**: 2220–2223.
- Janoušková S, Hák T, Nečas V, Moldan B (2019) Sustainable development—a poorly communicated concept by mass media. Another challenge for SDGs? *Sustainability* **11**: 3181.
- Jonsdottir KE, Hvas M, Alfredsen JA, Fore M, Alver MO, Bjelland HV *et al.* (2019) Fish welfare based classification method of ocean current speeds at aquaculture sites. *Aquaculture Environment Interactions* **11**: 249–261.
- Landbruksdirektoratet (2019) Norwegian Agricultural Agency. [Cited 31 October 2019.] Available from URL: <https://www.landbruksdirektoratet.no/no/statistikk/utvikling/antall-dyr/klekte-kyllinger>
- Lawrence AB, Vigers B, Sandøe P (2019) What is so positive about positive animal welfare?—a critical review of the literature. *Animals* **9**.
- Lien ME (2015) *Becoming Salmon: Aquaculture and the Domestication of a Fish*. University of California Press, Oakland.
- Lund V, Mejdell CM, Rocklinsberg H, Anthony R, Hastein T (2007) Expanding the moral circle: farmed fish as objects of moral concern. *Diseases of Aquatic Organisms* **75**: 109–118.
- Matloven (LOV-2003-12-19-124) The Norwegian Food Act. Matloven LOV-2003-12-19-124. Norwegian Ministry of Health and Care Services. [Cited 1 November 2019.] Available from URL: www.lovdata.no
- Mellor DJ (2016) Updating animal welfare thinking: moving beyond the “five freedoms” towards “a life worth living”. *Animals* **6**.
- Mellor D, Patterson-Kane E, Stafford KJ (2009) *The Sciences of Animal Welfare*. Wiley-Blackwell, John Wiley & Sons, Oxford.
- Mork O, Gulbrandsen J (1994) Vertical activity of four salmonid species in response to changes between darkness and two intensities of light. *Aquaculture* **127**: 317–328.
- NFSA (2018a) FOR-2018-03-23-481. Endr. i forskrift om kontrollområde for ILA, Kvinnerød, Tysnes, Stord, Sveio og Vindafjord. Norwegian Food Safety Authority. [Cited 10 October 2019.] Available from URL: www.lovdata.no
- NFSA (2018b) FOR-2018-07-20-1201. Forskrift om kontrollområde for (ILA), Alstahaug, Vevelstad og Vefsn. Norwegian Food Safety Authority. [Cited 11 October 2019.] Available from URL: www.lovdata.no
- NFSA (2018c) *Norwegian Food Safety Authority, 2018 Annual Report*. pp. 91. Norwegian Food Safety Authority, Oslo.
- NFSA (2019a) FOR-2019-02-01-59. Forskrift om kontrollområde for å forebygge, begrense og bekjempe infeksøs lakseanemi (ILA) hos akvakulturdyr, Rauma, Vestnes og Molde. Norwegian Food Safety Authority. [Cited 11 October 2019.] Available from URL: www.lovdata.no
- NFSA (2019b) Norwegian Food Safety Authority. [Cited 10 October 2019.] Available from URL: [; www.mattilsynet.no/https://www.mattilsynet.no/dyr_og_dyrehold/dyrehelse/nytt_dyrehelseregulering_i_eu_landdyr_og_akvatiske_dyr.7725](http://www.mattilsynet.no/https://www.mattilsynet.no/dyr_og_dyrehold/dyrehelse/nytt_dyrehelseregulering_i_eu_landdyr_og_akvatiske_dyr.7725)
- NFSA (2019c) Norwegian Food Safety Authority. [Cited 11 October 2019.] Available from URL: [; www.mattilsynet.no/https://www.mattilsynet.no/language/english/about_us](http://www.mattilsynet.no/https://www.mattilsynet.no/language/english/about_us)
- NFSA (2019d) Norwegian Food Safety Authority. [Cited 11 October 2019.] Available from URL: [; www.mattilsynet.no/https://www.mattilsynet.no/om_mattilsynet/maal_og_strategi.63](http://www.mattilsynet.no/https://www.mattilsynet.no/om_mattilsynet/maal_og_strategi.63)
- Noble C, Jones HAC, Damsgard B, Flood MJ, Midling KO, Roque A *et al.* (2012) Injuries and deformities in fish: their potential impacts upon aquacultural production and welfare. *Fish Physiology and Biochemistry* **38**: 61–83.
- Noble C, Gismervik K, Iversen MH, Kolarevic J, Nilsson J, Stien LH, Turnbull JF (eds) (2018) *Welfare indicators for farmed Atlantic salmon: tools for assessing fish welfare*. 351 p. Norway. [Cited 1 November 2019.] Available from URL: <http://www.nofima.no/fishwell/english>
- Osmundsen TC, Almklov P, Tveteras R (2017) Fish farmers and regulators coping with the wickedness of aquaculture. *Aquaculture Economics & Management* **21**: 163–183.
- Ot.prp. nr. 15 (2008–2009) Om lov om dyrevelferd. Ministry of Agriculture and Food. [Cited 10 October 2019.] Available from URL: <https://www.regjeringen.no/contentassets/4c83935a183e45ea92761d8b864383dd/no/pdfs/otp200820090015000dddpdfs.pdf>
- Ot.prp.nr.100 (2002–2003) Om lov om matproduksjon og mattrygghet mv (matloven). Ministry of Health and Care Services. [Cited 10 October 2019.] Available from URL: <https://www.regjeringen.no/contentassets/9d0aafa802c046d087feb773caef8ddb/no/pdfs/otp20022003010000dddpdfs.pdf>
- Overton K, Dempster T, Oppedal F, Kristiansen T, Gismervik K, Stien L (2018) Salmon lice treatments and salmon mortality in Norwegian aquaculture: a review. *Reviews in Aquaculture* **1**–20.
- Rocklinsberg H (2015) Fish consumption: choices in the intersection of public concern, fish welfare, food security, human health and climate change. *Journal of Agricultural & Environmental Ethics* **28**: 533–551.

- Seibel H, Weirup L, Schulz C (2020) Fish welfare—between regulations, scientific facts and human perception. *Food Ethics* 5 (1): 1–11.
- Stefansson SO, Nilsen TO, Ebbesson LOE, Wargelius A, Madsen SS, Bjornsson BT *et al.* (2007) Molecular mechanisms of continuous light inhibition of Atlantic salmon parr-smolt transformation. *Aquaculture* 273: 235–245.
- Stien LH, Bracke MBM, Folkedal O, Nilsson J, Oppedal F, Torgersen T *et al.* (2013) Salmon Welfare Index Model (SWIM 1.0): a semantic model for overall welfare assessment of caged Atlantic salmon: review of the selected welfare indicators and model presentation. *Reviews in Aquaculture* 5: 33–57.
- Thorud K, Håstein T (2003) Experiences with regulatory responses to infectious salmon anemia in Norway. In: Miller O, Cipriano RC (eds) *International Response to Infectious Salmon Anemia: Prevention, Control, and Eradication: Proceedings of a Symposium; 3–4 September 2002; New Orleans, LA*. Tech. Bull. No. 1902, pp. 155–159. U.S. Department of Agriculture, Animal and Plant Health Inspection Service; U.S. Department of the Interior; U.S. Geological Survey; U.S. Department of Commerce, National Marine Fisheries Service, Washington, DC.
- Tønnessen M (2018) Animals in Norwegian political party programs: a critical reading. In: *Framing the Environmental Humanities*, pp. 103–123. Brill Rodopi.
- Vigors B (2019) Citizens’ and farmers’ framing of “positive animal welfare” and the implications for framing positive welfare in communication. *Animals* 9.