THE WELFARE OF FARMED FISH

INTRODUCTION

The vast majority of European aquaculture involves intensive farming. We recognise that the UK industry (the one with which we are most familiar) has made some progress in tackling welfare problems. Nonetheless, both in the UK and elsewhere, intensive fish farming, whereby large numbers of fish are confined in a small area, causes serious welfare problems that need to be addressed urgently to prevent further widespread suffering.

Intensive aquaculture practices frequently expose fish to a range of stressors such as stripping of broodstock, handling, vaccinations, crowding, grading, starvation, sea lice treatments as well as loading and transport. Although they can be alleviated to some degree by good practice, these stressors are inherent in intensive aquaculture. The European Food Safety Authority (EFSA) has pointed out that common aquaculture practices can lead to injury, stress, increased disease susceptibility and impaired performance.[1]

Intensively-farmed fish suffer from a range of welfare problems including physical injuries such as fin erosion, eye cataracts, skeletal deformities, soft tissue anomalies, increased susceptibility to disease, sea lice infestation in the case of Atlantic salmon and high mortality rates.

It is well established that fish are likely to experience pain[2], fear and psychological stress and that, like other vertebrates, they have the capacity to suffer.[3] Accordingly, it is important that their welfare is safeguarded.

---

[1] Scientific Opinion of the Panel on Animal Health and Welfare on a request from the European Commission on animal welfare aspects of husbandry systems for farmed European seabass and Gilthead seabream. *The EFSA Journal* (2008) 844, 1-21

[2] Sneddon L.U., 2003. The evidence for pain in fish: the use of morphine as an analgesic. *Applied Animal Behaviour Science* 83 (2) 153-162.

[3] Chandroo K.P., Duncan I.J.H. & Moccia R.D., 2004. Can fish suffer?: perspectives on sentience, pain, fear and stress. *Applied Animal Behaviour Science* 86 (2004) 225-250.

SCALE OF THE AQUACULTURE SECTOR

About 50% of global fish production comes from aquaculture rather than from fish caught at sea.[4] Indeed, fish farming is the fastest growing sector in world production of animal-derived food with an average worldwide growth rate of 6-8% a year. With a global production of nearly 52 million tonnes in 2006, world aquaculture has increased by one third since the beginning of the millennium. One recent study predicts the collapse of all species of sea fish by 2048 if steep declines in fish populations continue at the present rate (collapse is defined as 90 per cent depletion).[5] This will inevitably lead to a major expansion of aquaculture.

This paper focuses on the welfare of farmed Atlantic salmon, rainbow trout, seabass and seabream; these are the main species farmed in Europe. It also looks at Atlantic cod and Atlantic halibut; these species are relatively new to aquaculture, but are being increasingly farmed in Norway, Scotland and Iceland.

European finfish aquaculture (including Norway and Turkey) produced 1.58 million tonnes in 2007.[6] Norway is Europe's largest producer, accounting for 53.2% of European production. The UK ranks second with 10.1% of Europe's production. Other major producers include Turkey (6.3%), Greece (4.6%), Spain (3.9%), Italy (3.8%), France (3.1%), Poland (2.4%), Denmark (2.4%) and Germany (2.2%).

Atlantic salmon dominates European aquaculture (926,928 tonnes in 2007), followed by rainbow trout (340,285 tonnes), gilthead seabream (95,207 tonnes), seabass (93,494 tonnes), common carp (64,963 tonnes) and cod (10, 600 tonnes).[7]

In 2009 the Commission produced a Communication setting out a new impetus for the Strategy for the Sustainable Development of European Aquaculture. The Communication encourages growth in European aquaculture while stressing that the development of the sector must be sustainable and achieve a high level of protection of fish welfare.[8] Council Conclusions adopted in June 2009

[4] Communication from the Commission to the European Parliament and the Council. Building a sustainable future for aquaculture: A new impetus for the Strategy for the Sustainable Development of European Aquaculture. COM(2009) 162/3.
[5] Worm, B., Barbier E.B., Beaumont N., Duffy J.E., Folke C., Halpern B.S., Jackson J.B.C., Lotze H.K., Micheli F., Palumbi S.R., Sala E., Selkoe K.A., Stachowicz J.J. and Watson R., 2006. Impacts of biodiversity loss on ocean ecosystem services. *Science* 314: 787-790.
[6] Figures from the Federation of European Aquaculture Producers.
[7] As 6.
[8] As 4.

endorse the Commission's objective of seeking growth in European aquaculture, while recognising the importance of fish welfare.[9] Nonetheless, Compassion in World Farming is concerned that fish welfare may be given insufficient attention as fresh impetus is given to growth of the aquaculture sector.

HEALTH PROBLEMS AND DISEASE

EFSA points out that "the intensification of fish farming has inevitably resulted in the emergence of disease problems, in particular of diseases of infectious origin although over recent years a number of issues relating to health and disease have been successfully addressed .through better husbandry and the introduction of vaccines".[10]

EFSA states that diseases in farmed fish are not caused by primary pathogens but are generally closely linked with the husbandry and environmental conditions under which the fish are being reared.[11] Many pathogens are ubiquitous in the environment or in the fish's tissues but only manifest themselves in a clinical fashion if stressful husbandry or environmental conditions facilitate their establishment, allowing a relatively poor infectious agent to overcome the defence mechanisms of the host.[12] EFSA concludes that disease in farmed fish is "generally an indicator of an underlying husbandry or environmental deficiency".[13]

Håstein writes that under farming conditions, fish "may reach the outer limit of their physiological margin due to maximal exploitation and stress, making them susceptible to a wide range of diseases threatening ethical and welfare standards".[14] Stress generally reduces the ability to fight disease. Moreover, keeping large numbers of fish in crowded conditions facilitates the transmission of infectious diseases.

---

[9] Council Conclusions on a Strategy for the Sustainable Development of European Aquaculture. 2952nd Agriculture and Fisheries Council meeting. Luxembourg. 22 and 23 June, 2009.
[10] Scientific Report of the Panel on Animal Health and Welfare on a request from the European Commission on animal welfare aspects of husbandry systems for farmed Atlantic salmon. *The EFSA Journal* (2008) 736, 1-122
[11] Scientific Report of EFSA prepared by Working Group on Trout welfare on Animal Welfare Aspects of Husbandry Systems for Farmed Trout. *Annex I to The EFSA Journal (2008) 796, 1-97*
[12] As 10
[13] As 11
[14] Håstein T., 2004. Animal welfare issues relating to aquaculture. Global conference on animal welfare: an OIE initiative.

Poppe and others point out that certain production-related or husbandry diseases have emerged concurrently with the intensification of husbandry practices.[15] These include various types of skeletal deformities, soft tissue malformations and cataracts.

Cataracts – and associated blindness – are a cause of concern in intensively farmed Atlantic salmon[16]. Skeletal malformations in farmed fish include spinal, head and jaw deformities as well as softness of the skeleton.[17] Deformities are a recurrent problem in farmed Atlantic salmon and other farmed species and EFSA states that the sustained production of deformed fish challenges he credibility of the industry and is an ethical issue of increasing importance.[18]

Certain soft tissue anomalies have been observed in recent years in Atlantic salmon such as ventricular hypoplasia (underdevelopment of chambers that pump blood out of the heart), situs invertus of the heart (upside-down heart) and deficient septum transversum (a cardiac deformity).[19] These factors may lead to reduced tolerance to stress and increased mortality.[20] A proportion of farmed salmonids have developed rounder hearts than wild fish.[21] Such abnormally shaped hearts are associated with poorer cardiac function and a higher mortality rate during stressful procedures such as grading, lice treatments and transport. Poppe and others emphasise that there is a major ethical dilemma in farming fish that, due to limited cardiac capacity, are predisposed to cardiac failure during certain common, but stressful, aquaculture procedures.[22]

The incidence of several of the diseases that until recently were a major problem in aquaculture has been substantially reduced through the development of effective vaccination and improved management. Some diseases however, such as *Infectious Pancreatic Necrosis,* continue to present serious problems. Whilst we accept that progress has been made through vaccination, one must be careful not to use veterinary medicines to mask poor husbandry and hygiene.

---

[15] Poppe T.T., Barnes A.C. & Midtlyng P.J., 2002. Welfare and ethics in fish farming. *Bull. Eur. Ass. Fish Pathol*. 22 (2), 148-151.
[16] As 14 & European Commission, 2004. Farmed fish and welfare. European Commission, Directorate-General for Fisheries, Research and Scientific Analysis Unit (A4). Brussels, Belgium.
[17] As 11
[18] As 11
[19] As 14 & 15
[20] As 14
[21] Poppe T.T., Johansen R., Gunnes G. & Torud B., 2003. Heart morphology in wild and farmed Atlantic salmon *Salmo salar* and rainbow trout *Oncorhynchus mykiss. Dis Aquat Org* 57 103-108.
[22] As 21

Moreover, vaccination has in some cases had adverse side effects. EFSA points out that are certain disadvantages regarding vaccination, in particular by injection,.[23] These are:

- ***Handling at vaccination;*** poor welfare and stress may be caused by crowding, catching, anaesthesia and pain associated with the vaccination and post-vaccination reaction.
- ***Growth retardation;***
- ***Deformities in the vertebral column;***
- ***Adhesions which later organise and contract as scar tissue in the peritoneal cavity.*** Peritoneal adhesions represent the most serious welfare issue in relation to the use of injectible vaccines.

Water quality and flow rate

Good water quality is essential for the health and welfare of farmed fish. Water is the source of oxygen and also plays a vital role in disposing of wastes; it dilutes faeces and, if there is sufficient water flow, it removes faeces and uneaten feed. Dissolved oxygen is essential for fish respiration; below a certain level, asphyxia and increased mortality occur. Persistent exposure to elevated levels of carbon dioxide is likely to lead to chronic pathologies. Un-ionized ammonia is highly toxic to fish. A Council of Europe Recommendation points out that the accumulation of ammonia can be avoided by, among other things, reducing stocking density.[24]

Poor water quality can lead to both acute and chronic health and welfare problems. In particular, it can give rise to acute or chronic stress, reduced ability to control homeostasis, increased susceptibility to and incidence of disease, reduced condition factor, increased fin erosion and gill damage, reduced growth and increased mortality.[25],

A crucial factor that determines water quality and hence carrying capacity (the maximum density that is consistent with good health and welfare) is the flow rate of incoming water; this influences the provision of dissolved oxygen and the dilution and dispersal of wastes such as faeces and uneaten feed.

---

[23] As 11
[24] Recommendation concerning farmed fish of the Standing Committee of the European Convention for the protection of animals kept for farming purposes, Article 12.
[25] Ellis T., North B., Scott A.P., Bromage N.R., Porter M. & Gadd D., 2002. The relationships between stocking density and welfare in farmed rainbow trout. *Journal of Fish Biology* (2002) 61, 493-531; &
North B.P., Turnbull J.F., Ellis T., Porter M.J., Miguad H., Bron J. & Bromage N.R., 2006. The impact of stocking density on the welfare of rainbow trout (*Oncorhynchus mykiss*). *Aquaculture* 5, 466-479.

Crowding, handling and grading

Fish are sometimes crowded to aid handling, for example prior to grading, counting, transport and slaughter. Crowding is undertaken in order to make it feasible to access fish; it involves gathering the fish into one section of the enclosure and leads to abnormally high stocking densities. Crowding is stressful and can lead to damage to scales, skin ulceration, eye and snout damage and bruising.[26]

Many farm activities – stripping, vaccination, tagging and marking, grading and splitting, loading prior to transport and unloading, movement to the stunning point - involve handling the fish and/or moving them around the farm.

Handling is stressful, particularly if it entails removal from the water. It can result in scale loss, injuries to eyes and fins and muscle bruising.[27] Handling can also lead to injuries to the skin, which is fishes' first line of defence against disease, and to damage to the mucous coating which secretes a protective layer over the skin and is a primary protection against pathogens and parasites.

Fish grow at varying rates. In natural conditions, smaller fish can avoid aggression by larger ones by moving away, but escape is difficult in the confined conditions of intensive farming and larger fish may bully smaller ones and prevent them from feeding or even cannibalise them. In order to minimise this, fish are periodically graded into different sizes. Fish may also be graded before slaughter to remove those not yet ready for slaughter. Grading is a stressful procedure [28] and can lead to physical injury to the fish.

Crowding, handling and grading are stressful and can cause injuries. Accordingly, they should be kept to a minimum. All farms should employ the methods used on the best farms and should keep up-to-date with developing best practice in this area. Fish should only be removed from water when absolutely necessary[29] and should not be kept out of water for more than 15 seconds unless anaesthetised.[30] Fish should not be kept crowded before slaughter for more than two hours.[31]

---

[26] Wall A.J., 2000. Ethical considerations in the handling and slaughter of farmed fish. *Farmed fish quality.* Eds. Kestin S.C. & Warris P.D., Oxford Fishing News Books 108-115.
[27] 14 & Willoughby, 1999. *Manual of salmonid farming.* Fishing New Books, Blackwell Science, Oxford.
[28] Dunlop R.A., Laming P.R. & Smith T.E., 2004. The stress of four commercial farming practices, feeding, counting, grading and harvesting, in farmed rainbow trout *Oncorhynchus Mykiss. Mar. Fresh. Behav. Physiol.*, Vol. 37, No. 3.179-192.
[29] Ashley P.J., 2006. Fish welfare: current issues in aquaculture. *Applied Animal Behaviour Science* (2006) (in press).
[30] HSA, 2005. Humane harvesting of salmon and trout: Guidance notes No. 5. Humane Slaughter Association, UK.
[31] As 30

STOCKING DENSITY

There is currently much debate about the effect of stocking density on welfare. Some argue that stocking density has no or little impact on the welfare of farmed fish. This, however, is not borne out by a careful examination of the scientific literature in this field. For example, EFSA has concluded that stocking density is a major factor affecting salmon welfare and that high stocking densities in salmon may lead to increased aggression levels, physical damage and decreased water quality.[32]

The literature indicates that stocking density is important as it is one of a range of factors – including water quality, flow rate of incoming water and feeding method - that interact to determine the welfare of farmed fish. Density cannot, however, be considered in isolation from other environmental factors. Water quality, in particular, has a fundamental role in determining welfare. One of the principal concerns about high stocking density is that it can lead to deterioration of water quality.

Norwegian scientists write: "There is a legitimate public concern that fish are kept at too high densities in intensive aquaculture".[33] Similarly, a UK researcher stresses: "Stocking density is a pivotal factor affecting fish welfare in the aquaculture industry, especially where high densities in confined environments are aimed at high productivity".[34]

High stocking densities can result in impaired welfare in cod. Feed intake and growth are significantly lower among cod stocked at 30 and 40kg/m^3 than in those stocked at 10kg/m^3.[35] Reduced feed intake and growth in fish are often seen as indicative of poor welfare. Stocking halibut at high densities appears to lead to higher stress levels, reduced feeding motivation, lower growth and stereotypic behaviour in some fish.[36]

---

[32] As 10

[33] Juell J-E., Oppedal F., Boxaspen K. & Taranger G.L. 2003. Submerged light increases swimming depth and reduces fish density of Atlantic salmon *Salmo salar L.* in production cages. *Aquaculture Research* (2003) 34*,*469-477.

[34] Ashley P.J., 2007. Fish welfare: current issues in aquaculture. *Applied Animal Behaviour Science,* Volume 104, Issues 3-4, May 2007, 199-235

[35] Lambert Y. & Dutil J-D., 2001. Food intake and growth of adult Atlantic cod (*Gadus morhua* L.) reared under different conditions of stocking density, feeding frequency and size-grading. *Aquaculture* 192 (2001) 233-247.

[36] Kristiansen T.S., Ferno A., Holm J.C., Privitera L., Bakke S. & Fosseidengen J.E., 2004. Swimming behaviour as an indicator of low growth rate and impaired welfare in Atlantic halibut (*Hippoglossus hippoglossus* L.) reared at three different stocking densities. *Aquaculture* 230 (2004) 137-151.

High stocking densities can have a detrimental impact on the health and welfare of Atlantic salmon and rainbow trout; In particular, high densities can lead to:

- **increased susceptibility to disease**; moreover once disease enters a crowded enclosure, high densities facilitate its transmission [37]
- **increased incidence of physical injuries** such as fin erosion. Fin damage is multi-factorial in its causation; high stocking density is not the sole cause. Nonetheless fin damage is increased at higher densities in both Atlantic salmon and rainbow trout.[38] Fin lesions increase susceptibility to pathogen infection[39]
- **poor body condition[40]**
- **increased stress[41]**
- **reduced growth**, **feed intake and feed conversion efficiency** in rainbow trout.[42]

All the above factors are indicative of a reduced welfare status. In addition, high densities can lead to:

- **poor water quality**. An increase in stocking density can result in deterioration in water quality (e.g. a reduction in dissolved oxygen concentrations and an increase in the level of un-ionized ammonia) as more fish are respiring and metabolising in a particular volume of water.[43] Moreover, greater fish densities result in an increase in the release of waste products into the enclosure
- **increased aggression** which leads to fin injuries, scale loss, chronic stress and subordinate fish being prevented from feeding by dominant fish.[44]

In addition to the science, practical experience indicates that lower densities produce benefits in terms of better performance, better feed conversion, better quality, better health, less disease, reduced fin damage, less size variation and improved survivability.

---

[37] As 14 & 16
[38] (a) Ellis T., North B., Scott A.P., Bromage N.R., Porter M. & Gadd D., 2002. The relationships between stocking density and welfare in farmed rainbow trout. *Journal of Fish Biology* (2002) 61, 493-531; &
(b) North B.P., Turnbull J.F., Ellis T., Porter M.J., Miguad H., Bron J. & Bromage N.R., 2006. The impact of stocking density on the welfare of rainbow trout (*Oncorhynchus mykiss*). *Aquaculture* 5, 466-479.
[39] As 38(b)
[40]As 38(a) & Turnbull J., Bell A., Adams C., Bron J. & Huntingford F., 2005. Stocking density and welfare of cage farmed Atlantic salmon: application of a multivariate analysis. *Aquaculture* 243, 121-132.
[41] Turnbull J., Bell A., Adams C., Bron J. & Huntingford F., 2005. Stocking density and welfare of cage farmed Atlantic salmon: application of a multivariate analysis. *Aquaculture* 243, 121-132.
[42] As 38(a)
[43] As 38(a)
[44] As 38(a)

Maximum stocking density

It is important not to stock up to a theoretical maximum but instead to provide a safety margin so as to ensure that, even when problems arise, fish continue to have good water quality and sufficient space for swimming. Farmers are not in control of all the factors – such as water quality and bad weather - that can adversely affect the fish. A safety margin is important to allow for harmful developments.

Research shows that above 22kg/m^3, increasing density is associated with lower welfare for caged Atlantic salmon.[45] However, in order to provide a safety margin, Compassion in World Farming believes that the maximum stocking density for Atlantic salmon in sea cages should ideally be 10kg/m^3, with farmers who achieve a high welfare status and in particular low levels of injuries, disease, parasitic attack and mortality being permitted to stock up to a maximum of 15kg/m^3.

The authors of the above study concluded that while stocking density can influence the welfare of Atlantic salmon in cages, it is only one influence on their welfare and on its own cannot be used to accurately predict or to control welfare. This conclusion is what one may expect as the probability with any species (both fish and terrestrial) is that a number of factors will be involved in determining welfare.

Research shows that rainbow trout stocked at 40 and 80kg/m^3 have significantly more fin damage than those stocked at 10kg/m^3 and that growth and feed intake are greater and size variation is reduced in rainbow trout kept at around 25kg/m^3 as compared with 70 and 100kg/m^3.[46] In light of these studies and practical experience, we believe that the maximum stocking density for rainbow trout and for Atlantic salmon in the juvenile freshwater stages should be 20-30kg/m^3, provided that the rate and quality of water flow is high.

Low densities

Current knowledge suggests that very low densities should be avoided as they can lead to aggression. Rainbow trout should not be stocked at 10kg/m^3 or below as research has indicated certain welfare problems at this density; the authors suggest this may be due to the existence of a dominance hierarchy.[47] Salmon too should not be stocked at very low densities. The advisability of

[45] As 41
[46] 38(b) & Boujard T., Labbé L. & Benoit A., 2002. Feeding behaviour, energy expenditure and growth of rainbow trout in relation to stocking density and food accessibility. *Aquaculture Research* 33, 1233-1242.
[47] As 38(b)

avoiding very low densities is not likely to be a problem in practice as the densities in question fall outside the range commonly used in commercial aquaculture.

The fact that welfare problems may arise at low densities indicates that fish are fundamentally unsuited to farming. Low densities do not present a problem in the wild where fish that are attacked by a con-specific are able to simply move away. However, in the confines of a cage or other enclosure, escape is not possible.

THE UNNATURAL ENVIRONMENT OF FISH FARMING

In the case of many species, farmed fish are kept in conditions that are far removed from their natural world and that constrain their normal behaviour.

Rearing salmon in cages constrains their natural swimming behaviour as it deprives them of swimming the great distances that are the norm for wild salmon at sea.[48] That constraint is exacerbated at high densities. High densities in cages induce Atlantic salmon to swim in schools, which may not be their natural behaviour in the wild for much of their time at sea[49] and which may be a behavioural adaptation to reduce the stress of the high density environment in commercial cages.[50] Research is needed to examine whether any detrimental impact on the health and welfare of Atlantic salmon and rainbow trout results from the constraints placed on their natural swimming behaviour by intensive aquaculture.

Trout larvae hatch from eggs deposited in a stream bed. As their gills and internal organs develop trout gradually move downstream before residing in a river or lake or, in the case of sea going populations, in the sea. Adults migrate upstream to lay their eggs.[51] The environment for farmed trout is far removed from their natural habitat. In aquaculture trout are kept in a range of systems including concrete raceways, tanks and cages.

[48] Juell J-E., 1995. The behaviour of Atlantic salmon in relation to efficient cage rearing. *Reviews in Fish Biology and Fisheries* 5, 320-335. &
Sedgwick S.D., 1988. *Salmon Farming Handbook.* Fishing News Books Ltd, Farnham, England.
[49] As 48
[50] Juell J-E., Johansson D. & Oppedal F., 2006. Effects of the cage environment and social interactions on the swimming behaviour and welfare of Atlantic salmon. In: Damsgard B., Juell J-E. & Braastad B. Welfare in farmed fish. *Fiskeriforskning* (Norwegian Institute of Fisheries and Aquaculture Research) 20 January 2006.
[51] As 11

The conditions prevalent in hatcheries and on-growing farms for Atlantic halibut are in stark contrast to their natural environment.[52] Halibut are sedentary fish that spend most of their time resting on the bottom.[53] In aquaculture, however, halibut are on-grown in onshore tanks and sea cages where stocking densities are very high resulting in high levels of contact and interactions between individuals which may well be stressful.[54] Researchers report that halibut stocked at high densities left the bottom relatively frequently, due to being disturbed by other fish, and engaged in surface swimming which may be viewed as an indication of impaired welfare in largely sedentary fish.[55]

Seabream is a sedentary fish, living solitary or in small schools.[56] Most farmed European seabream, however, are on-grown in sea cages stocked, once the fish are older, at a density of 10-20kg/m^3.[57]

Seabass are commonly found in estuarine areas and coastal lagoons which they enter during summer, retuning to the sea in winter. In contrast to this, farmed seabass are usually kept in cages.

Aggression

Aggression occurs among many farmed fish species. It may be caused by high, or in some species, very low stocking densities and by competition for feed and sites close to feeders.[58]

Transport

Juvenile fish are often transported to farms or sea cages to be fattened. On reaching slaughter weight, they are in some cases transported to the slaughter plant. Loading and transport can cause extensive stress in fish.[59] The capture/loading process is for most species the most stressful part of transport.[60] During transport, fish can sustain injuries from physical interaction with other fish or

---

[52] Greaves K. & Tuene S., 2001. The form and context of aggressive behaviour in farmed Atlantic halibut (*Hippoglossus hippoglossus* L.) *Aquaculture* 193 (2001) 139-147.
[53] As 36
[54] As 36
[55] As 36
[56] Scientific Report of EFSA prepared by Working Group on seabass/seabream welfare on Animal Welfare Aspects of Husbandry Systems for Farmed European seabass and gilthead seabream. *Annex I to The EFSA Journal (2008) 844, 1-89.*
[57] As 56
[58] 11 & 56
[59] Iversen M., Finstad B. & Nilssen K.J., 1998. Recovery from loading and transport stress in Atlantic salmon (*Salmo salar* L.) smolts. *Aquaculture* 168 (1998) 387-394.
[60] EFSA, 2004a. Opinion of the Scientific Panel for Animal Health and Welfare on a request from the Commission related to the welfare of animals during transport. *The EFSA Journal* (2004) 44, 1-36.

abrasion with the tank walls.[61] Poor conditions during transport, such as overcrowding and inadequate water quality, may result in irreparable damage to the fish and mortality.[62]

Transporting fish poses a significant risk of spreading disease. Because of this and the welfare problems involved, Compassion in World Farming is opposed to the transport of live fish over long distances. Transport must be kept to an absolute minimum. We concur with a Norwegian aquaculturalist's conclusion that "local production of eggs and juveniles and local processing [slaughter] is the answer".[63]

Starvation

Atlantic salmon and rainbow trout are often starved for several days, sometimes for two weeks or more, before slaughter to empty the gut. Such prolonged periods of starvation are unacceptable from the welfare viewpoint. Starvation periods should be kept as short as possible and should not exceed 72 hours.[64] Seabass and seabream are also starved prior to slaughter in order to firm the flesh and empty the gut.[65]

Starvation or feed reduction is also sometimes used to adapt production levels to the market situation. The purpose is to keep the fish off the market when market prices are low in the hope that prices will rise before the fish have to be sold. We believe that the use of starvation as a market-regulating mechanism should not be allowed on welfare grounds.

Tagging

So far fish have mainly been tagged for identification purposes in research. Some now advocate the tagging of farmed fish so that, in the event of escapes, it will be possible to distinguish farmed from wild fish, to monitor escapees and to trace the farms concerned. In addition, tagging may at some stage be promoted to ensure traceability from the fjord to the table.

---

[61] Cooke S.J., Suski C.D., Ostrand K.G., Tufts B.L. & Wahl D.H., 2004. Behavioural and physiological assessment of low concentrations of clove oil anaesthetic for handling and transporting largemouth bass (*Micropterus salmoides*). *Aquaculture* 239 (2004) 509-529.

[62] Rosten T., Rosseland B.O., Salbu B., Olsvik P. & Steen J.E., 2005. Documentation of fish welfare: experiences and recommendation of fish transportation in open-, closed-, and combined well boat transports. Conference: lessons from the past to optimise the future. *European Aquaculture Society:* Special Publication No. 35.

[63] Myrseth B., 2005. What we have learned from fish farming and how we can apply this for future developments. Conference: lessons from the past to optimise the future. *European Aquaculture Society:* Special Publication No. 35.

[64] FAWC, 1996. Report on the Welfare of Farmed Fish. Farm Animal Welfare Council, UK.

[65] As 56

We are opposed to any extension of tagging. The handling and restraint of fish involved in tagging are stressful and the insertion of tags can be painful and cause wounds and lead to infections.

Sea lice infestation

Intensive farming has led to sea lice infestation becoming a serious welfare problem for farmed salmon in many areas. EFSA has stressed that sea lice "are emerging as the biggest economic and welfare risk of all farmed salmon in the marine environment".[66]

Wild salmon range over a wide area, thereby minimising the opportunity for sea lice to find hosts. However, when thousands of salmon are kept in sea cages, they tend to attract substantial numbers of lice.

If untreated, sea lice infestation can lead to fish suffering greatly and dying. Current treatments include the use of in-feed or bath chemicals that have possible adverse environmental effects. More 'environmentally-friendly' methods - hydrogen peroxide and the use of wrasse to eat the lice off the salmon - have serious animal welfare drawbacks. Hydrogen peroxide is highly aversive to the fish and can cause mortalities. It is not acceptable to take wrasse from the wild and place them in cages where they suffer high mortalities due to starvation, bullying and being eaten by larger salmon.

Sea lice infestation should be controlled by improved management including careful site selection, complementary management procedures such as treating all the farms in an area at the same time, the separation of year classes and periodic fallowing of cage sites to break the cycle of parasite infection.

Algal blooms and jellyfish

Algal blooms may occur in both fresh and marine waters. They can produce gill or nerve poisons, remove oxygen from the water, cause respiratory distress and, in the worst cases, lead to mass mortality, especially in caged fish in open water systems.[67]

In sea cages fish are at risk from jellyfish.[68] Some jellyfish species have long trailing tentacles with stinging cells that can burn and even blind farmed fish. Unable to see properly, fish drift into the net mesh, which can result in heavy scale loss and consequent secondary infection. EFSA points out that

---

[66] As 32
[67] As 11
[68] As 11

dense swarms of jellyfish may occasionally be washed into cage sites. Mortalities and other severe adverse effects are due to anoxia or obstruction of respiration by the sheer volume of jellyfish, or to severe external injuries caused by the nematocysts (venomous cells) on the tentacles.[69]

Confined in cages, farmed fish are unable to evade algal blooms and jellyfish. The ethical acceptability of fish farming is called into question by the fact that it makes it impossible for fish to move away from dangers that they could avoid in the wild.

Predation

EFSA stresses that attacks by predators are a major welfare problem and that "repeated or prolonged attack, or traumatic wounding, must cause suffering".[70] Fish that are injured during an attack but not killed have to undergo a period of recovery or decline and death. Attacks by predators can also cause a stress response in the whole population.[71]

Some farmers shoot seals as part of predator control. Wild mammals and birds should not be shot or otherwise harmed as an anti-predator measure.

Every precaution should be taken to avoid predators gaining access to the fish through the use of anti-predator nets as well as the selective use of scarers and decoys.

Mortality

Mortality rates for salmon smolts reared in sea cages are high when compared with other farmed animals, amounting in Scotland to about 22%. A leading researcher has questioned whether survival rates below 80-90% can be considered acceptable for food producing animals kept under human custody.[72]

In Scotland, average survival rates tend to be below 80%. The mortality rate for the 37 million smolts put to sea in Scotland in 2003 was 21.9%[73], which means that around 8.1 million fish died after being put to sea and before slaughter. Such high mortality rates would rightly sound alarm bells in other branches of farming.

---

[69] As 11
[70] As 11
[71] As 56
[72] As 15
[73] FRS, 2007. Fisheries Research Services. Scottish fish farms annual production survey 2007.

We recognise that in the wild mortality rates can be high due to predation. Farmed fish, however, are in general not subject to large-scale predation and accordingly it should be possible to keep mortality rates to a much lower level.

BIOTECHNOLOGY, GENETIC SELECTION AND GENETIC ENGINEERING

All-female fish and triploidy

Early sexual maturation in several species, particularly in males, presents problems for farmers. Sexually mature fish undergo changes that can reduce flesh quality. Moreover, if they escape, sexually mature fish can interbreed with wild stocks, thereby impairing their genetic integrity and reducing their chances of survival.

The industry uses sex reversal to produce batches of all-female fish, as in several species females mature later than males, thereby enabling the fish to be grown to greater weights. Sex reversal involves feeding the male sex hormone, testosterone, to young female fish. Sex reversal is now commonly practised in some salmonid species, carp and tilapias.[74]

Triploidy is a method of producing sterile fish by subjecting newly-fertilised eggs to heat or pressure shock. The resulting fish are induced to have triploid (three) sets of chromosomes instead of the usual diploid (two). The process is commonly used in conjunction with sex-reversal to produce sterile, all-female fish. Sterile female fish will not reach sexual maturity and so are able to be reared to greater weights without incurring the deterioration in flesh quality that accompanies maturation. In addition, sterile fish that escape will not endanger wild populations by inter-breeding.

Triploids are susceptible to a range of health and welfare problems, including higher levels of spinal deformities, eye cataracts, poorer growth and lower survival rates.[75] Compassion in World Farming believes that biotechnology techniques involving chromosome manipulation (e.g. sex reversal and triploidy) should be prohibited. We recognise that sex reversal does not entail any proven welfare

[74] As 11

[75] Madsen L., Arnbjerg J. & Dalsgaard I., 2000. Spinal deformities in triploid all-female rainbow trout (*Oncorhynchus mykiss*). *Bull. Eur. Ass. Fish Pathol*. 20 (5) 2000. pp. 206-208. & Jhingan E., Devlin R.H & Iwama G.K., 2003. Disease resistance, stress response and effects of triploidy in growth hormone transgenic coho salmon. *Journal of Fish Biology* 63, No. 3 806-823. & Johnson R.M., Shrimpton J.M., Heath J.W. & Heath D.D., 2004. Family, induction methodology and interaction effects on the performance of diploid and triploid chinook salmon (*Oncorhynchus tshawytscha*). *Aquaculture* 234 (2004) 123-142 & . Wall A.E. & Richards R.H., 1992. Occurrence of cataracts in triploid Atlantic salmon (*Salmo salar*) on four farms in Scotland. *Veterinary Record* 31: 553-557.

problems. Nonetheless, we are concerned about it on ethical grounds and believe that the practice should be monitored to establish whether or not it has an adverse effect on welfare.

Selective breeding

Selective breeding is widely used in aquaculture to produce fish that grow more rapidly and to attain improved feed conversion rates, delayed sexual maturation and greater resistance to disease. However, EFSA points out that there is a possibility that selection for resistance to one disease may compromise resistance towards another.[76]

Almost 100 % of global farmed Atlantic salmon production, about 25% of global farmed rainbow trout production and 70% of EU farmed trout production are based on stocks that have been subject to selective breeding.[77] Selectively bred salmon grow twice as fast as wild salmon. Selective breeding for faster growth and disease resistance has started in seabass and seabream aquaculture but this is not yet routine.[78]

Intense selection for fast growth or enhanced productivity has led to serious health problems in other farmed species such as meat chickens and dairy cows. We fear that farmed fish could soon begin to experience analogous health and welfare problems if the drive to accelerated growth rates continues unabated. Indeed, fast growth rates are already associated with an increased incidence of cataracts and abnormal heart shape and function.[79] EFSA has pointed out the lack of data on the possible negative effects of genetic selection on functional systems (respiratory, cardiac, locomotion, reproduction) and disease susceptibility.[80] EFSA has recommended that genetic selection of salmon should take into account possible consequences for their welfare of any changes.[81]

Genetic engineering

Genetic engineering techniques have been developed for aquaculture. These can push fish to even further extremes than traditional selective breeding. They threaten to push back the boundaries of

[76] As 10
[77] As 11 & Gjedrem T., Gjerde B. & Rye M., 2005. Lessons from developing breeding programs for aquaculture species. Conference: lessons from the past to optimise the future. *European Aquaculture Society:* Special Publication No. 35.
[78] As 56
[79] As 21 & Ersdal C., Midtlyng P.J. & Jarp J., 2001. An epidemiological study of cataracts in seawater farmed Atlantic salmon (*Salmo salar). Dis Aquat Org.* 45: 229-236.
[80] As 11
[81] Scientific Opinion of the Panel on Animal Health and Welfare on a request from the European Commission on Animal welfare aspects of husbandry systems for farmed Atlantic salmon. *The EFSA Journal* (2008)736, 1-31

intensification and cause yet more suffering for farmed fish. Researchers are working on fish that grow faster and larger, convert feed into flesh more efficiently, are resistant to disease, tolerant of low levels of oxygen in the water and can withstand freezing temperatures. Growth-enhanced transgenic Atlantic salmon have been produced that can grow 3-6 times faster than ordinary salmon.

Genetic engineering has led to serious health and welfare problems in fish. A major Canadian report concluded that unintended disadvantageous changes to the phenotype are the rule rather than the exception in the genetic modification of fish.[82] Expression of transgenes may have unintended adverse effects on many systems affecting the fitness of the fish, including tolerance to disease and stress.[83]

Serious deformities have been documented in coho salmon genetically engineered for accelerated growth, with abnormalities in the cranium, jaw and operculum due to excessive cartilage deposition.[84] This resulted in affected individuals suffering feeding and breathing difficulties and poor viability.[85] Moreover, reduced swimming abilities have been documented in growth-enhanced transgenic coho salmon.[86]

Farm escapes are already implicated in the decline of wild salmon stocks. Transgenic escapees threaten to have an even worse effect. They could displace wild fish through superior ability in securing food; they could also jeopardise wild fish by interbreeding with them, thereby undermining their genetic make-up and so producing fish less able to survive in the wild.

We are opposed to the development of genetically engineered fish for use in aquaculture.

---

[82] Royal Society of Canada, 2001. Elements of precaution: recommendations for the regulation of food biotechnology in Canada. An expert panel report on the future of food biotechnology prepared by the Royal Society of Canada.
[83] Jhingan E., Devlin R.H & Iwama G.K., 2003. Disease resistance, stress response and effects of triploidy in growth hormone transgenic coho salmon. *Journal of Fish Biology* 63, No. 3 806-823.
[84] Devlin R.H., Yesaki T.Y., Donaldson E.M., Du S.J. & Hew C-L., 1995a. Production of germline transgenic Pacific salmonids with dramatically increased growth performance. *Canadian Journal of Fisheries and Aquatic Sciences* 52: 1376-1384. & Devlin R.H., Yesaki T.Y., Donaldson E.M. & Hew C-L., 1995b. Transmission and phenotypic effects of an antifreeze/GH gene construct in coho salmon (*Oncorhynchus kisutch*). *Aquaculture* 137 (1995) 161-169.
[85] Dunham R.A. & Devlin R.H., 1999. Comparison of traditional breeding and transgenesis in farmed fish with implications for growth enhancement and fitness. In: *Transgenic Animals in Agriculture*. Eds: Murray J.D., Anderson G.B., Oberbauer A.M. & McGloughlin M.M. CAB International.
[86] Kaiser M., 2005. Assessing ethics and animal welfare in animal biotechnology for farm production. *Rev. sci. tech. Off. Int. Epiz*. 2005, 24 (1) 75-87.

Artificial lighting and photoperiod manipulation

Photoperiod, or the number of hours of daylight in a 24-hour period, can be manipulated, for example by the use of lamps positioned above or in the water. Such manipulation is used in Atlantic salmon to (i) vary the timing of spawning in order to obtain a supply of eggs for an increased proportion of the year, (ii) vary the timing of smoltification to produce smolts for transfer to seawater for an increased proportion of the year, (iii) reduce sexual maturation as this impairs flesh quality and (iv) increase growth. Photoperiod manipulation is used in rainbow trout to produce eggs out of season and to promote growth.

Manipulation of photoperiod is also used to advance or delay the spawning time in seabass and seabream in order to produce eggs out of season.[87] Continuous light regimes are currently under investigation in seabass farming in order to reduce the proportion of early sexually maturing males.[88]

Relatively little research has been undertaken on the welfare implications of photoperiod manipulation, although studies have found that artificial photoperiods affect the immune system of rainbow trout and hence their susceptibility to pathogenic microorganisms.[89] EFSA states that the welfare consequences of artificial photoperiod treatments are not clear.[90] However, they point out that the use of light in Atlantic salmon to accelerate growth and stimulate early out of season smoltification has been associated with lowered skeletal mineralisation and bone strength, suggesting a possible link to skeletal deformities in under-yearling smolts.[91]

Research is needed to investigate whether any further adverse welfare implications arise from photoperiod manipulation. Such research should in particular examine:

- **if accelerated growth leads to health and welfare problems:**
  The increase in growth can be substantial; continuous light on salmon cages in winter can produce 20-30% greater growth. Accelerated growth rates are a source of serious health and welfare problems in terrestrial animals. It cannot be presumed that fish are immune to analogous dangers

---

[87] As 1
[88] As 1
[89] Burgos A., Valenzuela A. Gonzalez M. & Klempau A., 2004. Non-specific defence mechanisms of rainbow trout (*Oncorhynchus mykiss*) during artificial photoperiod. *Bulletin of the European Association of Fish Pathologists* 24: 240-245.
[90] As 11
[91] As 10

- **if continuous lighting could lead to health and eye problems:**
  Continuous lighting can lead to serious problems in terrestrial animals such as, in chickens, increased stress and fearfulness, reduced responsiveness of the immune system and eye abnormalities including blindness. It cannot be assumed that fish are not susceptible to being adversely affected by continuous lighting

- **if artificial lighting may lead to stress:**
  Atlantic salmon reduce feed intake for the first 6-12 weeks after the lights are turned on; this indicates a stress situation

- **if the transfer of smolts to sea in autumn has any adverse welfare implications:**
  The natural seaward migration of wild smolts takes place in spring. Research needs to be undertaken to investigate if the practice of placing smolts in the sea at unnatural times such as autumn has any adverse welfare implications. Wild smolts experience long summer days after migrating to the sea, but this is not the case for farmed smolts transferred to seawater in autumn. Poor growth and variable growth have been reported in smolts transferred in autumn.

Compassion in World Farming is concerned about the use of artificial lighting regimes and believes that welfare is likely to benefit if fish are kept with natural light patterns.

HOUSING CONDITIONS

Cage netting should be smooth and non-abrasive to prevent injuries to the snout, fins and scales. Freshwater enclosures should be constructed of materials that minimise the potential for injuries.

Biological fouling is the process whereby various organisms – such as mussels, algae and marine bacteria – settle on to and colonise a surface such as the nets of a cage. If unchecked, biological fouling can lead to very substantial reductions in water flow through cages and hence to reduced oxygen levels and increased levels of fish wastes and ammonia in the water. Cleaning of fouled nets is essential.

FEEDING METHOD

The feeding method used must minimise competition and hence aggression and ensure that all the fish have access to feed.

ENVIRONMENTAL ENRICHMENT

There seems to be reasonably broad recognition that environmental enrichment may be beneficial for fish welfare, but little detailed research appears to have been undertaken. The Fisheries Society of the British Isles has said that a degree of environmental complexity may be important, depending on the species concerned.[92]

BREEDING METHODS

Invasive techniques are used to remove eggs and sperm from Atlantic salmon and rainbow trout. Female salmon are anaesthetised. A stockperson then releases the eggs by a firm stroking of the abdomen. Some facilities introduce compressed air through a needle into the abdominal cavity of the anaesthetised fish to push out the eggs. Alternatively, the salmon is killed, after which her eggs are removed surgically. Female rainbow trout are stripped manually by a stroking motion; sometimes they are sedated before stripping. Sperm is extracted from anaesthetised male salmon by stroking the abdomen.

Compassion in World Farming is concerned about these methods of obtaining eggs and sperm, some of which are invasive and involve removing the fish from water. That said, in Scotland fish are anaesthetised prior to stripping. We believe that this should be a normal part of best practice; our view is that all fish should be anaesthetised prior to stripping.

Assessment of seabream and seabass sex and sexual maturation is usually performed by manual stripping; EFSA points out that this involves handling stress.[93] Sex may be determined by urogenital catheterization biopsy; this is an invasive stressful procedure that may threaten fish health.[94] All sexing methods involve crowding, netting, handling, and anaesthesia.[95]

Cod aquaculture is heavily reliant on wild caught broodstock to maintain high levels of larval production.[96] Seabream and seabass broodstock may be wild or farmed. Wild fish are currently preferred by the industry to maintain genetic variability in the broodstock; but EFSA points out they have to be conditioned to captivity for at least six months to recover from stress before being used

---

[92] FSBI, 2002. Fish Welfare. Briefing Paper 2, Fisheries Society of the British Isles, Granta Information Systems, 82A High Street, Sawston, Cambridge, UK. 29 October 2002.
[93] As 1
[94] As 1
[95] As 1
[96] Bell G., Blanco A., Roy B., Robertson D., Henderson J. & Prickett R., 2005. Optimisation of diets for Atlantic cod (*Gadus morhua*) broodstock: effect of arachidonic acid on egg & larval quality. The British Marine Finfish Association Annual Workshop 2005, Oban, Scotland.

as broodstock.[97] The use of wild-caught fish for aquaculture is unacceptable both because, in the case of some species, it further reduces severely depleted wild stocks, and because wild fish are ill-equipped to adapt to the unnatural environment of aquaculture.

THREATS TO WILD STOCKS FROM FARMED FISH

Farmed Atlantic salmon jeopardise the long-term sustainability of wild salmon as a result of escapes and the transmission of sea lice from salmon farms to wild fish. A new study concludes that there is convincing evidence that salmon farms are the most significant source of sea lice in juvenile wild salmonids in Europe and North America and can be a significant cause of mortality on nearby wild fish populations.[98] Wild Atlantic salmon numbers have fallen dramatically over the last 30 years. Up to two million salmon escape each year from farms in the North Atlantic. In some Norwegian rivers and coastal areas a high proportion of salmon are of farmed origin. The detrimental impact of farmed salmon on wild fish may arise in three ways:

- competition for feed and habitat
- transfer of diseases and parasites, particularly sea lice
- interbreeding with wild fish, leading to dilution of genetic integrity and impaired survival.

FARMING OF NEW SPECIES

Increasingly, new species such as Atlantic cod and Atlantic halibut are being introduced into intensive fish farming. The principal European farmed species – Atlantic salmon and rainbow trout – suffer from a range of welfare problems. We do not wish to see new species being exposed to similar problems. Accordingly, we are concerned about the introduction of new species into farming; at the very least there should be a moratorium on the use of new species until farmers are able to demonstrate that humane rearing, transport and slaughter methods have been developed for that species.

Atlantic cod

High stocking densities can result in impaired welfare in cod. We believe that the maximum stocking density for cod should be 10-15kg/m^3.

---

[97] As 1
[98] Costello M J, 2009. How sea lice from salmon farms may cause wild salmonid declines in Europe and North America and be a threat to fishes elsewhere. *Proc. R. Soc. B* published online 8 July 2009. doi: 10.1098/rspb.2009.0771

Many of the factors that lead to poor welfare in farmed Atlantic salmon and rainbow trout are also present in cod farming: cod are aggressive[99] and so need to be size-graded;[100] they can suffer from anatomical deformities such as spinal deformities and a range of diseases.[101] Moreover, they are often subjected to continuous artificial lighting in order to delay maturation. In addition, a proportion of broodstock are caught from the wild. Indeed, in Iceland and Norway a proportion of the cod that are farmed (not just the broodstock) have been captured from the wild for on-growing on farms.[102]

Atlantic halibut

The conditions prevalent in hatcheries and on-growing farms for Atlantic halibut are in stark contrast to their natural environment.[103] There are severe problems at the juvenile production stage for halibut, resulting in a wide range of survival rates. Aggression is common in young halibut during feeding, with injuries being sustained to the eyes, fins and tails.[104] Stocking halibut at high densities appears to lead to higher stress levels, reduced feeding motivation, lower growth and stereotypic behaviour in some fish.[105]

In cages, fish cannot avoid hazards from which, in the wild, they would flee

Confining fish in sea cages is ethically dubious as this exposes them to dangers from which, in the wild, they would simply move away. In cages, however, fish are unable to escape hazards such as predators, jelly fish, algal blooms, sea lice and poor water quality.

Organic and Freedom Food standards

We have reservations about the application of the term 'organic' to caged fish. However, organic standards and those of the RSPCA's Freedom Food scheme demonstrate that it is practicable to farm fish to significantly higher standards of welfare than those of conventional intensive farming. For

---

[99] Höglund E., Øverli Ø. & Winberg S., 2005. The role of dietary tryptophan in animal welfare. Conference: lessons from the past to optimise the future. *European Aquaculture Society:* Special Publication No. 35.
[100] Imsland A.K., Foss A., Folkvord A., Stefansson S.O. & Jonassen T.M., 2005. Differences in growth, food conversion efficiency and anatomic deformities in juvenile Atlantic cod in relation to start feeding scheme. Conference: lessons from the past to optimise the future. *European Aquaculture Society:* Special Publication No. 35.
[101] Bricknell I., Bron J., Tarrant P. & Urquhart K., 2005. An update on diseases in gadoid fish. The British Marine Finfish Association Annual Workshop 2005, Oban, Scotland.
[102] Midling K., 2005. Capture-based farming of cod – the Norwegian history and state of the art. Conference: cod farming in Nordic countries, Reykjavik, Iceland, 2005. & Wilhelm, 2005. Advancements of Icelandic aquaculture in cod and halibut. The British Marine Finfish Association Annual Workshop 2005, Oban, Scotland.
[103] As 52
[104] As 52
[105] As 36

example, the Soil Association lays down a maximum stocking density for Atlantic salmon in saltwater net pens of 10kg/m^3 +/-1%. The Soil Association's maximum density for trout is 20kg/m^3 +/-2% in running freshwater operations and 10kg/m^3 +/-1% in net pens. Also welcome is the Soil Association's prohibition on the use of triploid, all-female and genetically engineered stock. The Organic Food Federation has produced standards for farmed cod that contain a number of valuable provisions. The standards set a maximum stocking density of 15kg/m^3 which we welcome.