IN TOO DEEP

THE WELFARE OF INTENSIVELY FARMED FISH

A REPORT FOR

COMPASSION IN WORLD FARMING TRUST

BY

PHILIP LYMBERY
ANIMAL WELFARE CONSULTANT

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ABOUT THE AUTHOR

Philip Lymbery is an international animal welfare consultant. In 1992, his report, The Welfare of Farmed Fish, was the UK's first to look at the welfare issues in salmon and trout farming. This was written whilst working for Compassion In World Farming (1990-2000), where he spent the last 7 years as Campaigns Director. Maintaining a special interest in fish welfare, Philip submitted both written and oral evidence to the subsequent investigation of the industry by the Government's advisory Farm Animal Welfare Council. He has also been advisor to the Aquaculture Standards Committee of organic farming body, the Soil Association.

Philip Lymbery can be contacted at:

Turnstone Campaigns
2 Meon Close
Petersfield
Hampshire
GU32 3DW
United Kingdom
Tel: +44 (0)1730 231534
Email: philip@turnstones.com

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EXECUTIVE SUMMARY

Farmed fish now represent the UK's second largest livestock sector after broiler chickens. The vast majority of the 70 million farmed fish produced annually in the UK are reared intensively. 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.

Caged & Crowded

Up to 50,000 salmon are confined in each sea cage. They are reared at stocking densities equivalent to each three quarters of a metre long (2.5 ft) salmon being allocated a bathtub of water. Packed this tightly, these natural wanderers of the ocean swim as a group, or shoal, in incessant circles around the cage, like the pacing up and down of caged zoo animals. Fins and tails become worn and damaged as the fish rub against the cage sides or each other.

The stress of crowding and confinement can manifest itself in increased susceptibility to disease. The eye of a fish is highly sensitive to disease or stress. In recent years, high incidences of severe cataracts have been found in intensively farmed salmon and other species. These often cause blindness. Researchers have described these cataracts as a "production disease" potentially affecting any industrial scale intensive fish farm. They go on to say that "Perhaps more important than the economical losses are the animal welfare aspects, which in the long term may arouse doubts on the ethical standards of industrial fish farming among consumers".

Salmon farming has also been hit by waves of serious disease outbreaks, such as Furunculosis and Infectious Salmon Anaemia, causing the deaths of millions of fish. Farmed salmon suffer high rates of mortality. Average losses of 10-30% of fish are experienced during the sea-rearing phase alone. Such high mortality rates would raise serious alarm bells in other farm animal species.

Norwegian farmed salmon can be affected by "humpback" where fish have deformed backs, all too often causing their bodies to look like carp rather than the sleek, elongated shape of a healthy salmon.

Trout are stocked at even higher densities. Generally reared in freshwater raceways or earth ponds, trout can be stocked at densities of 60 kg of fish per cubic metre of water (60 kg/m^3). That is equivalent to 27 trout, each measuring a foot (30 cm) long, being allocated a bathtub of water. More normal rates are 30-40 kg/m^3. This compares with 15-20 kg/m^3 on Scottish sea cage farms for salmon. Tight stocking of trout again leads to them suffering high levels of injuries to fins and tails, adversely affecting their welfare.

The prevalence of fin and tail injuries, disease outbreaks, blinding cataracts, deformities, abnormal behaviours, serious infestation of salmon by sea lice, and high rates of mortality make it clear that current commercial stocking densities for farmed fish are too high. Maximum stocking densities of 10 kg/m^3 for juvenile salmon at sea, and 20 kg/m^3 for trout reared in freshwater should be introduced urgently through legislation. Further reductions should be considered in the light of future practical and scientific evidence, taking full account of welfare indicators such as abnormal behaviour, injuries, disease, parasitic attack, and mortality.

Parasite Infestation

Intensive farming has led to sea lice becoming the greatest single problem for farmed salmon in many areas. Sea lice are small parasitic crustaceans that feed on their host causing fish to lose skin and scales. Lice damage around the head can be so severe that the bone of the living fishes' skulls can be exposed – a condition known as the "death crown". Sea lice infestation is a serious welfare problem, which if untreated, can lead to considerable suffering and death in affected fish.

Large numbers of tightly confined fish, together with poorly chosen farm sites, can exacerbate problems with these parasites. Sea lice should be dealt with by moving away from high stocking densities and intensive management, and through careful site selection. Sites should have clean, fast-flowing water to reduce the likelihood of serious parasitic attack.

However, current treatments centre on the use of strong nerve toxins that have possible environmental effects. Organophospates and synthetic pyrethroids are used to bath fish that are crowded together in a small amount of water. The procedure itself causes the fish a great deal of stress. A new generation of in-feed treatments for sea lice are now becoming available. These avoid the need for subjecting the fish to stressful crowding and bathing in chemicals, as the chemical treatment is incorporated in the feed. However, residues from these oral treatments are feared to pose a potential danger to wildlife on the seabed.

Some methods of treating sea lice are seen as environmentally friendly. Bathing of fish in hydrogen peroxide, for example, and the use of wrasse, a group of species known as "cleaner" fish because they eat lice directly off the salmon. Both methods have serious animal welfare drawbacks. Crowding fish together is stressful in itself. Subsequently bathing them with a chemical irritant, hydrogen peroxide, is highly aversive to the fish, even causing some to die. Using wrasse as "cleaner" fish is far from welfare-friendly for the wrasse and is questionable on environmental grounds. In 1996, some 3 million wrasse, were taken from the wild for use against sea lice on Norwegian salmon farms. Wrasse often suffer high mortalities from starvation, bullying, being eaten by larger salmon, or dying from the stress of capture and transport to the farm, representing a serious animal welfare problem. Therefore, hydrogen peroxide and wrasse for treating sea lice are both unacceptable on welfare grounds.

Grading for Size

Fish grow at varying rates. Under confined conditions, larger fish may bully smaller ones, or even cannibalise them. This is minimised on the farm by periodic 'grading' or sorting into different sizes. Grading is a stressful management procedure for fish and may be carried out 3-5 times during the rearing cycle. It usually entails fish being netted or pumped out of their aquatic environment over a series of bars or slats. They drop through the bars according to size. Comparative work is needed to assess the welfare aspects of different grading methods using non-invasive techniques. This work should compare the levels of stress caused by the different grading systems, looking at how much physical damage they cause to the fish (e.g. scale loss and abrasions), the length of time fish go off their feed, and the post-grading ‘growth check’ – the drop in growth rate in the days immediately after grading. The stress caused to the fish by grading should be minimised.

Transport

Salmon fry are generally reared in freshwater tanks, cages or ponds. In the spring, they undergo physical changes that allow them to tolerate seawater. These ‘smolts’, or juvenile salmon, are then transferred to sea farms with the help of lorries, helicopters and well boats. Similarly, trout may be transported from the hatchery to the rearing farm or for slaughter. Most trout are transported on flatbed lorries. Movement and transfer can be a frightening experience for fish, and has been described by industry experts as causing “considerable” stress. To protect fish welfare, transport times should be reduced to the absolute minimum. Water conditions for the fish in transit, such as oxygen levels, carbon dioxide, and pH, should be monitored at frequent intervals.

Biotechnology, Sex-Reversal & Genetic Engineering

Biotechnology to produce chromosome-manipulated fish known as “triploid” is widely used in the UK trout industry. Newly fertilised eggs are subjected to heat or pressure shock so that cells carry three sets of chromosomes instead of the normal two. This causes the resulting fish to be sterile, thereby delaying sexual maturity and the resulting reduction in flesh quality, as well as increasing their efficiency in converting feed into flesh. It also causes a range of health and welfare problems. Triploid fish have been found with higher levels of spinal deformities, breathing difficulties, low blood haemoglobin levels, a lowered ability to cope with stressful situations, and higher rates of mortality.

The triploidy process is usually used in conjunction with a technique to induce all-female fish through sex reversal. This involves feeding the male sex hormone, testosterone, to young female brood fish, and using their eventual sperm to produce later maturing female only fish, allowing them to be reared for longer without adversely affecting flesh quality. Tens of millions of trout eggs are produced annually in Britain this way. CIWF Trust believes that biotechnology techniques involving chromosome manipulation (e.g. sex reversal and triploidy) should be prohibited. These are already prohibited under UK organic standards for fish farming.

Current industrial fish farming is highly intensive. Genetic engineering using transgenic methods (e.g. putting human or animal growth hormone genes into fish) threatens to increase the level of intensification still further, potentially causing even more suffering to farmed fish. Genetic engineering can also cause welfare problems in itself, with transgenic salmonids for example, having difficulties breathing, feeding, and developing normally. Fish, in common with other farm animals, are sentient beings that can experience suffering. Genetic engineering should not be used to further relegate them to the status of animal machines. The use of genetically engineered fish for farming should be prohibited.

Starvation & Slaughter

Farmed fish are normally starved for about 7-10 days before slaughter. It is said that this is to empty their gut and minimise the risk of the flesh becoming contaminated when gutted. However, gut clearance only takes 24-72 hours. Farmed fish are conditioned over months and years to expect frequent and plentiful feed. To suddenly cut off that feed is highly likely to be detrimental to their welfare. CIWF Trust believes that starvation periods of longer than 72 hours should be prohibited.

About 35 million each of salmon and trout are slaughtered annually in the UK. That represents more animals than all the pigs, sheep, cattle and turkeys killed altogether. Some widely used slaughter methods for farmed fish cause appalling suffering. So much so that the perpetrators would be prosecuted if they were slaughtering other farm animals in a similar way. Widely used slaughter methods in the trout industry, for example, include the suffocation of fish in air or on ice. In the latter method, the cooling effect of the ice prolongs the time it takes for the fish to become unconscious. The fish are able to feel what is happening to them almost 15 minutes after being taken out of the water. The Government's advisory Farm Animal Welfare Council (1996) condemned this killing method, recommending that it be prohibited. Five years on and it is still in widespread use.

Another inhumane slaughter method often used for salmon and trout is the use of carbon dioxide stunning. The bath of carbon dioxide saturated water causes the fish to thrash around the killing container. They stop moving after 30 seconds, but do not lose consciousness for 4-9 minutes. Salmon usually have their gills cut after stunning and are allowed to bleed to death. The prolonged procedure is inhumane in itself. However, as carbon dioxide causes immobility long before unconsciousness, there is a real danger that fish remain conscious but unable to move as they bleed to death.

Inhumane and totally unacceptable slaughter methods, that can take a long time for fish to lose consciousness and die, should be prohibited urgently. These include suffocating fish in air or on ice, bleeding to death without pre-stunning, and the use of carbon dioxide for stunning.

Only slaughter methods that cause an instant death or render the fish instantly insensible to pain until dead should be permitted. These include percussive stunning techniques whereby fish are rendered instantly unconscious when carried out efficiently. Also electrocution methods where properly designed and carried out effectively. In the case of electrocution, the electric current must be sufficient to stun and kill the fish otherwise considerable suffering could result.

The Role of Retailers

A recent survey of the UK's top-10 biggest retailers found that most supermarket trout and some salmon were slaughtered using methods that are totally unacceptable on welfare grounds. Suffocation in air or on ice, both methods that cause a prolonged time to unconsciousness, are widely used to kill trout sold in supermarkets. Some salmon destined for major multiples are stunned using carbon dioxide before bleeding, another method condemned on welfare grounds.

The same survey found that salmon on sale in supermarkets have often been starved for 7-14 days before slaughter. Most standard sea cage-reared supermarket salmon will be kept at a maximum stocking density of 15-20 kg of fish per cubic metre of water. Freshwater-reared standard trout are generally kept at maximum densities of 30 kg fish/m^3 of water, but some can be kept at double this density.

Supermarkets have enormous influence over the animal welfare standards used to produce the fish they sell. CIWF Trust calls on those supermarkets selling farmed fish to raise their welfare standards by demanding that suppliers rear fish at greatly reduced stocking densities, use only humane slaughter methods, and stop the practice of prolonged pre-slaughter starvation.

Dead Seals & Declining Salmon

Intensive fish farming has resulted in cheap salmon and trout being readily available at the supermarket checkout. However, the true cost includes the suffering of the fish themselves, and the damage inflicted on the environment. Huge numbers of fish in one place form an irresistible attraction to wildlife such as fish eating birds, seals, mink and otters. Some farmers have seen the killing of wild animals as a legitimate part of predator control. So much so, that the real price of farmed salmon includes the killing of an estimated 3,500 seals around Scottish fish farms each year. CIWF Trust believes this appalling destruction of wildlife is entirely unacceptable. Wildlife should not be shot, drowned or otherwise harmed as an anti-predator measure.

CIWF Trust believes that every precaution should be taken to avoid predators gaining access to stock through the use of anti-predator nets and other non-lethal deterrents.

It is often claimed that fish farming may take the pressure off stocks of wild-caught fish by providing an alternative. However, the reverse is true. The farming of carnivorous fish such as salmon, trout, halibut and cod adds to the pressure on wild fish stocks and is therefore environmentally unsustainable. Over 3 tonnes of wild-caught fish are needed to produce 1 tonne of farmed salmon. Each tonne of farmed trout takes nearly 2.5 tonnes of wild fish to produce. For the newly farmed marine species such as halibut and cod, the ratio is over 5 times the weight of wild fish to produce an equivalent amount of farmed fish.

Escapes from fish farms have become a fact of life. During 2000, 411,000 salmon escaped from fish farms, approaching twice the number from the previous year. The situation with farm escapes, coupled with a decline in wild salmon, has become so bad that escaped farmed salmon now outnumber catches of wild salmon by seven to one. ‘Genetic pollution’ from escapees breeding with wild salmon can have a detrimental effect on the survival of wild populations. This is because wild fish are genetically adapted to life in their local environment. Any genetic mixing can reduce their ability to cope and survive. This is compounded by wild fish becoming infested with sea lice from salmon farms, causing increased death rates. The link between farmed salmon and declines in wild fish stocks is now recognised as being at near-crisis level. CIWF Trust believes that action must be taken to drastically reduce the impact of farmed fish and farm escapes on wild fish populations.

Alternatives & Consumers

The sheer scale and intensity of fish farming in Europe causes serious welfare problems. In recent years, organic farmers have been developing an alternative. Organic fish farming offers consumers a semi-intensive alternative to industrially reared salmon and trout. Fish are reared at lower stocking densities and with strict slaughter standards, giving UK organic standards strong welfare-friendly credentials. However, the standards currently allow the treatment of salmon sea lice using parasite-eating wrasse as "cleaner" fish and bathing in the chemical irritant, hydrogen peroxide, both methods that are not welfare-friendly. Along with allowing fish to be starved for 7-10 days before slaughter, these are welfare oversights that need to be addressed.

An extensive alternative already widely practiced in Japan and Alaska is sea ranching. This involves rearing young fish such as salmon, and releasing them when they would naturally migrate to sea. The fish then grow out at sea where they feed on a natural and totally unrestricted basis. When they mature, the fish return to their release river where they can be captured. Allowing fish to grow in their natural environment has potential for high welfare. However, the fish face increased natural threats such as predation and food shortage. The potential for sea ranching to damage wild stocks through interbreeding – genetic pollution – requires urgent attention before embarking on any venture of this nature.

Previous advice to consumers worried about the welfare, environmental and health aspects of farmed fish was to buy only wild fish. However, wild salmon populations have since declined in the UK, and wild fish is difficult to come by. Fresh wild salmon is much more expensive than farmed fish. Tinned wild Pacific salmon from the west coasts of Canada and the USA is more readily available.

Alternatively, some supermarkets are now stocking fresh organic salmon and trout. These are produced less intensively, are described as free from artificial chemicals and colorants, and are reared to higher welfare standards. To make sure that a fish is organic, the labels on the packaging or tags must read "farmed" and "organic", and will carry the symbol of the relevant organic organisation.

New European Union legislation requires that, from 1st January 2002, fish must be labelled according the production method (taken at sea or farmed). This compulsory labelling law should help those consumers wishing to avoid intensively farmed fish.

Conclusion

Farmed fish now represent the UK's second largest livestock sector after broiler chickens. The vast majority of the 70 million farmed fish produced in the UK are reared intensively, whereby large numbers of fish are confined in a small area. Intensive rearing methods, together with often appallingly cruel and widely used slaughter practices such as suffocation on air or on ice, and carbon dioxide stunning, are unacceptable on welfare grounds. Urgent action is needed to stop the widespread suffering of intensively farmed fish.

SCOPE OF THE REPORT

This report focuses on the welfare of farmed fish during rearing, transport and slaughter in Europe. European fish farming is dominated by the production of salmon and trout. This report reflects that fact by concentrating on the welfare of these salmonids, whilst looking at other selected fish species in a separate section.

Which Species are Covered?

The principle salmon species covered is the Atlantic salmon (Salmo salar). However, some references are also made to the Pacific salmons; Chum salmon (Oncorhynchus keta), Sockeye salmon (Oncorhynchus nerka), Pink salmon (Oncorhynchus gorbuscha), Coho salmon (Oncorhynchus kisutch) and Chinook salmon (Oncorhynchus tschawytscha).

Salmon have only been farmed intensively for about 30 years. This recent history means that they have not been altered a great deal from wild stock by selective breeding. After hatching and growing in freshwater, wild juvenile salmon migrate to sea. Those from British rivers may roam the ocean as far afield as Greenland and the Norwegian Sea. They feed on a diet of crustaceans and fatty fish such as sandeels, capelin and herring. After several winters at sea, less than 10% survive to return to their home river to breed. Some return after just one winter at sea. These early maturing fish are known as grilse.

Rainbow trout (Oncorhynchus mykiss) is the “farmer’s fish” of the trout family and has been reared for the table since the late nineteenth century. The Brown or Sea trout (Salmo trutta) is also farmed.

Other species of farmed fish including eels, sea bass and sea bream, cod, halibut and turbot are also covered in this report.

What is Animal Welfare?

Animal welfare is a concept that is often misunderstood. Fish farmers often believe that if a fish, or any other animal, remains alive and growing, then its welfare is good. This is not necessarily the case, especially where animals are kept under intensive conditions and given drugs to stave off disease.

The welfare of an individual animal has been described as “its state as regards its attempts to cope with its environment” (Fraser & Broom, 1990). If the animal has difficulty coping with an inadequate environment due to overcrowding, or other adverse factors, then it will experience stress. Animals under stress often show abnormal patterns of behaviour, for example, bar-biting in confined pigs. Long-term stress can also lead to animals being more prone to disease. In fish, disease or ill health are common indicators of poor welfare. Whilst drugs can be used to treat the disease, alterations to the farming system are needed to improve the animal’s welfare.

There are two component parts to welfare; production-related welfare – keeping the animal alive and growing; and quality of life aspects of welfare – preventing the animal from suffering as a result of behavioural or environmental deprivation.

To protect the overall welfare of a farmed animal requires a system that has the potential to achieve high standards of welfare, together with skilled levels of stockmanship and management. It is important to acknowledge that high levels of stockmanship and management are prerequisites to good animal welfare. Nevertheless, the *potential* to achieve high standards of welfare is inescapably linked to, and limited by, the husbandry system employed. Limiting factors include the housing system or aquatic environment, the breed of animal used, the feeding regime, and the presence or absence of harmful practices such as mutilations. By maximising the welfare potential of fish farming systems, the fish are not only encouraged to remain alive and growing, but their quality of life, or well being, is also protected.

INTRODUCTION

Fish farming is the world's fastest growing sector of food production. Consumer demand for fish is increasing. At the same time, wild fish stocks are in rapid decline due mainly to over-fishing. The global production of animal protein from aquaculture has been increasing by 10% each year since the mid-1980's, far outstripping increases in land-based farm animal production, which range from 0.7% (beef) to 5.2% (poultry) (Dunham & Devlin, 1999).

Salmon and trout form the mainstay of the European fish farming industry. The environmental problems, indicative of an over-intensive industry, have been well documented. The welfare of farmed fish has been given much less attention. About 70 million salmon and trout are farmed and slaughtered in the UK alone each year, making farmed fish the second largest livestock sector after poultry. Yet, protecting the welfare of these fish has been the subject of official procrastination.

Compassion In World Farming (CIWF) highlighted serious welfare problems in fish farming in 1992 when it published the UK's first report on the subject. Four years later, the UK Government's welfare advisory body, the Farm Animal Welfare Council (FAWC), published its report, which showed that, in certain areas, welfare conditions were even worse than first documented by CIWF. FAWC (1996) made 131 recommendations for action.

The British Government issued a response to FAWC 2 years later, announcing several priorities for research, mainly into slaughter methods and stocking densities. Its main response was to announce the development of Government welfare codes of practice to cover farmed fish. Of themselves not legally binding, many welfarists see codes of practice as weak and inadequate in the face of serious welfare issues. By December 2001 at least, the Government had still not published these codes.

This study by CIWF Trust shows that serious welfare problems still remain five years after the FAWC Report. Slaughter methods that are often cruel and unacceptable, high stocking densities, injuries, blinding cataracts, long periods of starvation, and infestation of salmon with parasitic sea lice continue to cause suffering to millions of fish.

Public attention recently has focused on the salmon industry. It now produces about 35 million farmed salmon a year, and continues to expand rapidly. There are welcome signs that some within the salmon industry are making efforts to improve the welfare of their fish. There seems a growing acceptance that better welfare means a better quality product. However, improvements are far from universal, and there remains much to be done. An on-going inquiry into the environmental effects of salmon farming by the Scottish Parliament shows that serious concerns remain over intensive salmon production. Legislation is needed urgently from both Scottish and Westminster Parliaments to make high welfare a requirement, not an option.

The trout industry has received less public attention. Ironically, the welfare problems are often even worse than with salmon. Trout are often crammed into pens at much higher stocking densities than salmon. Appalling slaughter methods that cause great suffering are still in widespread use for trout. FAWC (1996) recommended that killing trout through suffocation on ice should be prohibited. Despite this clear statement, this cruel method continues to be widely practised.

Fish farming has developed rapidly into a major livestock industry. Cod, halibut and turbot have now joined the inventory of British farm animals. One common misconception is that fish farming takes the pressure off wild fisheries. For carnivorous fish like salmon and trout, this is quite wrong. Several times more wild fish are used as feed to produce the same quantity of farmed fish. Fish farming can no longer be viewed as a short term phenomena or marginal practice. An informed debate is vital to better shape its future.

The welfare of farmed fish cannot be left to chance or good will. It is not acceptable for welfare to rely on industry self-policing. At best this leads to standards being applied patchily. As in other areas of agriculture, legislation is needed urgently to stop the widespread and intolerable suffering of millions of farmed fish. This study identifies key areas of current welfare concern, reviews progress in those areas, and calls for comprehensive legislation, to protect the welfare of farmed fish.

THE LIFE CYCLE OF FARMED FISH

The vast majority of farmed fish in Europe are reared intensively. Rearing is generally characterised by large numbers of fish at high stocking density. Lighting, water temperature, feeding regime and breed selection are often manipulated to increase production. The fish are confined in a range of pens, tanks, fast-flowing raceways and earth ponds. Management techniques can differ between species and different development stages of the fish.

REARING SYSTEMS FOR FISH

Hatcheries

The life cycle on a fish farm begins when eggs are stripped from the parent or 'brood' stock before being fertilised. Female fish are anaesthetised by being immersed in a solution of a suitable chemical such as Benzocaine. A stockman massaging the fish's abdomen releases the eggs. Once stripped of her eggs, the female is either put into a tank to recover ('mended') and be used again, or killed. Some facilities introduce compressed air through a needle into the abdominal cavity of the female fish to push out the eggs. Another method for salmon is to kill the anaesthetised female before stripping and remove the eggs surgically.

Massaging the abdomen of the male fish is used to collect sperm or 'milt'. An alternative is to use a syringe or pipette to extract the sperm directly from the male's vent. Males can be used 10 or more times before being killed.

To give an idea of the scale of operation, in Scotland, 21,721 female salmon were stripped in 1999, yielding 122 million eggs. Fertilised eggs are transferred to incubator trays and placed along a trough with flowing water. On hatching, the trays are removed and the newly hatched alevins – nourished by their yolk sac - develop in the trough. When they start feeding, the tiny fish are called fry and begin to move from the bottom of the tank and swim in the water column.

On-Growing in Freshwater

When the fish have grown to be as long as your finger, the fingerlings are transferred for on-growing. Fingerling trout and salmon 'parr' are reared in freshwater tanks, cages, ponds or raceways.

Rainbow trout are usually reared in raceways or rectangular earth ponds with a continuous flow of water. Unlike salmon, they are usually reared in freshwater until slaughtered. Trout farming is at its most intensive in raceways where the fast-flowing, well-oxygenated water allows fish to be kept at higher stocking densities without dying through lack of oxygen. Rainbow trout are generally a much smaller fish than salmon. Fingerlings take 1 year or more to reach slaughter weight as 'portion' sized trout at 0.2-0.4 kg. Alternatively, they may be on-grown to a weight of 1.8-2.75 kg, with some being reared in seawater.

Salmon parr are commonly raised in freshwater tanks and cages. Parr grow rapidly through the winter. In the spring, most will undergo changes of appearance and physiology that enable them to tolerate seawater. At this point, the juveniles are known as smolts. Those that change after one year are known as S_1 smolts. Others take two years and are called S_2 smolts. By varying water temperature and day length using artificial lighting to mimic spring, parr can be made to smolt six months early (Darbyshire, 2000). This further intensification means that salmon can be made to grow so fast they can be slaughtered in the same year as put to sea (FRS Marine Laboratory, 2000). This contrasts with more normal growth rates where the fish will be killed after 1-2 full years of rearing in seawater.

Rearing in Seawater

When young salmon are ready to migrate to sea, they are known as 'smolts'. At this point, they are transferred to sea farms, often with the help of lorries, helicopters and well boats. Almost all salmon smolts are reared in sea cages. Most cages are sited in coastal lochs or fjords, but offshore sites are now being established. Floating net cages are the most common type used, and come in a range of shapes; square, circular, octagonal, hexagonal and rectangular. They consist of a floating walkway, below which is a suspended bag-net enclosing the fish. Individual cages are often joined together to form larger farm units.

A typical sea cage measures 12-20 metres square and can be from 5-20 metres deep. Round cages can have a circumference of 40-100 metres (Fish Farmer, Mar/April 1998). Cages appear to be getting bigger, meaning that each fish has a greater volume of water overall to move in. However, stocking densities in larger cages are not likely to be lower, so the number of fish per cage will increase in proportion to cage size, resulting in bigger shoals. One sea cage confines 5,000 to 50,000 salmon.

Smolts are reared in sea cages for 1-2 years and are slaughtered at an average weight of 3.7-4.4 kg. Some smolts will begin to mature sexually after just one year at sea. These fish are known as 'grilse' and are killed for market before full sexual maturity reduces the quality of the carcass. They weigh an average 3.3 kg.

THE STRUCTURE OF THE INDUSTRY

The ‘king of fish’ – the Atlantic salmon – is by far the most economically important farmed fish in Europe. Salmon farming developed in the 1970’s and has expanded rapidly since. Norway reigns supreme as the largest producer of farmed salmon in Europe and the world. In 1999, 412,000 tons of salmon were produced; almost double its output of 1995. Norway was the first to develop sea cage farming.

Scotland is Europe’s second biggest producer of salmon. In 2000, over 128,000 tons or about 32 million salmon were slaughtered for the market. Other European salmon producers include Ireland, the Faroe Islands and Iceland. Canada, USA, Chile, Japan and New Zealand rank amongst the world’s important salmon producers.

Europe’s second most important farmed fish economically is the Rainbow trout, a species native to the coastal rivers of North America. Again, Norway is the biggest producer, slaughtering 50,000 tons of trout in 1999 - about 125 million fish. Italy, Denmark, Germany, Finland, Spain and the UK are other big trout producers in the region.

A wide range of other fish species is now farmed in Europe. Sea bass and Sea bream are widely farmed in Mediterranean countries, whilst traditional carp rearing is prominent in Eastern Europe. A lot of attention is being given to developing species new to farming such as cod, halibut and turbot.

THE UK INDUSTRY

Salmon

UK salmon production is predominantly a Scottish industry. Salmon are reared in two distinct phases; the hatchery and freshwater rearing of juveniles known as parr; and the seawater stage of rearing smolts – juveniles that are physiologically adapted to life in a marine environment.

In 2000, 60 companies in Scotland operated 184 freshwater sites, mainly for rearing salmon parr. Freshwater rearing took place mainly in tanks (97 sites) and cages (88 sites), with 7 sites using ponds or raceways. In the same year, 90 companies operating 346 sites were engaged in seawater salmon production, mainly along the Scottish west coast, the Western Isles, Orkney and Shetland. Official statistics show that 1,397 people were directly employed by the industry, and produced 128,959 tonnes of salmon (FRS Marine Lab., 2001). The number of people employed per tonne of fish produced has dropped dramatically in recent years, representing further intensification of the farming system.

Salmon farming represents over 95% of all sea cage fish farming in Scotland. In 1996-97, 20% of all salmon farming companies in Scotland controlled 78% of total production. Two companies dominated the Scottish industry in 1997, producing about half the entire salmon output (Willougby, 1999). There has been a trend towards increasing foreign ownership of Scottish salmon farms, with non-Scottish companies in 1996 owning almost 50% of farms (Scottish Parliament, 2000).

Scottish salmon farming is claimed to be worth more to the Scottish economy than the Highland beef and lamb industries combined according to Scottish Quality Salmon, the industry's trade body (SQS, 2000).

In England and Wales in 1999, 23 sites were engaged in salmon farming, the majority producing young fish to be reared in Scotland. However, 3 tonnes of salmon were slaughtered for consumption (CEFAS, 2000a).

Trout

In 1999, a total of 4,858 tonnes of Rainbow trout were produced for the table in Scotland, 6,710 tonnes in England & Wales, and 1,350 tonnes in Northern Ireland. These figures represent the rearing and slaughter of about 35 million individual fish in 1999, and were produced on a total of 262 UK farms (CEFAS, 2000a; CEFAS, 2000b).

FISH REARING AND WELFARE

Fish farming in Europe has become industrialised and highly intensive. About 70 million farmed fish are reared and slaughtered annually in the UK alone. Large numbers of tightly packed fish are reared in each sea cage, tank or pen. Some 20,000 salmon may be kept in a sea cage that measures 20 metres square and is 10 metres deep. If the fish were stocked at 20 kg/m^{3}*, each salmon about three quarters of a metre long (2.5 ft) would have approximately the same amount of water as in the average bathtub. Of course, the fish would be able to swim throughout the entire volume of water in the cage. But this analogy gives an idea of how tightly the fish are forced to swim together or "shoal".

Beneath the Surface – Crowded Fish & Poor Welfare

Taking a look below the surface, there are clear signs that all is not well for the welfare of farmed fish. Evidence of abnormal behaviours, widespread injuries, deformities, blinding cataracts, disease, parasitic infestation and high rates of mortality, all point to rearing conditions that result in poor welfare. One of the key determinants of good or bad welfare is stocking density – the amount of animals in a given amount of space. The Government's advisory body, the Farm Animal Welfare Council (FAWC, 1996) described stocking density as a "crucial factor affecting fish welfare". Crowding fish, or any other farmed animal, at high stocking densities can prevent them carrying out their natural behaviours, causing them to suffer chronic stress, making them susceptible to disease and attack from parasites.

Salmon farmers in Scotland were formerly stocking sea cages at maximum densities of 25-30 kg/m^3. Recent years have seen stocking densities reduced to 15-20 kg/m^3 (a 2.5 ft salmon in a bathtub), largely as a measure to limit disease outbreaks. In Norway, sea cages continue to be stocked at 25-30 kg/m^3.

Freshwater stocking rates tend to be even higher than those used in seawater. Salmon parr in Scotland are stocked at 30-50 kg/m^3 of freshwater. In 1999, the average stocking rate of parr in freshwater tanks was the equivalent of 83 of these young fish in a bathtub of water.

FAWC (1996) found trout stocking densities as high as 60 kg/m^3, although more normal rates were 30-40 kg/m^3. Continuing with the bathtub analogy, 60 kg/m^3 is the equivalent of keeping 27 'portion sized' trout about a foot long (30 cm) in that amount of water. FAWC's members noted a high degree of fin injury and suggested "stocking densities may be too high in all trout farms." UK trout stocking densities are believed to range currently from 20-120 kg/m^3 or more. Not surprisingly, the amount of damage noted to the fins of the fish is said to increase at higher densities. This damage is caused by the tightly packed fish rubbing against each other or their pen, or from nibbling at each other.

*Stocking density is usually described in terms of kilograms of fish per cubic metre of water. This reflects the three-dimensional environment inhabited by many species of fish including salmon and trout. Some flatfish, on the other hand, are bottom dwellers and stocking for these species is more often given as weight of fish per square metre.

Abnormal Behaviours & Injuries

Abnormal patterns of behaviour in farm animals are recognised as an indicator of poor welfare. These include pointless, repetitive behaviours such as bar-biting in confined pigs, for example. Another welfare indicator is the presence of widespread injuries or physical abnormalities within groups of animals. During its investigation of fish farming, FAWC (1996) noted that smaller fish were seen to remain around the outer edges of the cage. FAWC also found that some fish can be prevented from feeding, and were forced to take evasive action by dominant fish. These are behaviours indicative of a less than optimum rearing environment. FAWC described fin injury as “evident in most of the salmon” its members saw and suggested that this was as a “consequence of stocking densities which were too high.”

Salmon are kept at higher stocking densities in freshwater than in seawater. Young salmon during the freshwater phase of their life cycle – parr - tend to be naturally territorial. This territorial behaviour is suppressed as stocking rates rise. The fish then collect together and move as a group, known as shoaling behaviour.

Rainbow trout tend to be reared in freshwater. This species is described as a socially aggressive animal that will form social hierarchies dependent on size differences between fish. In the farm situation, socially submissive fish can be prevented from feeding and suffer higher mortality. For this reason, the fish need to be sorted, or “graded”, according to size (Pottinger & Pickering, 1992).

Studies of farmed fish have shown that the intensity of social interaction amongst groups of territorial fish is greatest when stocking densities are at an intermediate level (Pickering, 1992). So, contrary to what one might expect, the fish show less aggression at high densities. This does not necessarily mean that the welfare of the fish is any better at these higher stocking densities. It is well known in laying hens, for example, that aggression can diminish at both low and very high stocking densities. The band of maximum aggression in hens is found at intermediate stocking densities (Al-Rawi & Craig, 1974; Baxter, 1994). This can be interpreted as low stocking densities providing hens with optimum space, whereas very high densities inhibit not only normal socially acceptable behaviours, but even aggressive behaviour as well, indicating poor welfare. The welfare of hens and fish is likely to be best at the lower densities, but poorest at the highest. This suggests that the relationship between social interaction and stocking density for these species is not linear, but dome-shaped. Aggression peaks at medium stocking densities, and falls at both extremely high and low densities. Therefore, the level of aggression on its own should not be taken as an indicator of good or bad welfare. Other factors must also be considered.

In his book, the “Salmon Farming Handbook”, Sedgwick (1988) says;

> “Salmon are animals genetically programmed to spend most of their lives swimming freely through the oceans. We now confine them in tanks or cages in close proximity and frequent physical contact with thousands of others. In the open seas they would probably never have come as close to any other fish of their own kind before returning to spawn”.

Adult male salmon that have returned to freshwater will show territorial behaviour. Territorial behaviour is not usually shown in sea-going salmon. These wanderers of the ocean are also believed not to form huge, tight shoals at sea. However, they will mass in shoals when preparing to migrate back to their home river to spawn. This natural behaviour contrasts sharply with that shown by commercial salmon smolts in sea cages. These swim as a shoal, or large group, in circles around their cage. Given that fish growing in cages are not at the life stage where they naturally mass in shoals to migrate, it appears that shoaling in incessant circles around the cage is repetitive abnormal behaviour. This behaviour could well be remniscent of caged big cats pacing in small zoo pens.

Cataracts & Blind Fish

Severe cataracts, which can cause the fish to go blind, have been increasingly found in intensively farmed salmon in Norway, Scotland and Ireland (Waagbo, et al, 1998; Bjerkas & Bjornestad, 1999; Wall & Bjerkas, 1999). This obvious welfare problem has only recently become widely apparent. High incidences of this condition, which appears as a whitish clouding of the eye, have been found since the mid-1990's. The fish eye is a delicate organ and one of the first to be affected by disease or stressful situations. Advanced stages of cataract can cause bleeding and damage to the cornea, as well as blindness (Willoughby, 1999). The problem is believed caused by a combination of nutritional and environmental factors, and has been described by a Norwegian fish pathologist as being "very common" in farmed salmon (Poppe, 2001).

And it is not only intensive farmed salmon that are affected. Cataracts are also known to affect farmed halibut, Rainbow trout, Sea bass and Sea bream (Bjerkas, et al, 2000). The problem has become so bad that a consortium called "Friends of Blind Fishes" has been formed to search for a solution. Researchers have described cataracts as a "production disease" that potentially affects any intensive farming of fish on an industrial scale. They go on to say that "Perhaps more important than the economical losses are the animal welfare aspects, which in the long term may arouse doubts on the ethical standards of industrial fish farming among consumers" (Midtlyng, et al, 1999).

Deformed Salmon

Another production disease is a condition known as "humpback". Up to 70% of Norwegian farmed salmon are affected by humpback, whereby the fish have raised and deformed backs. Their bodies look more like those of a carp rather than the sleek, elongated shape of a healthy salmon.

Humpback has been described as "very common" in Norway with an affliction rate of 20% being considered "fairly ordinary". An important factor in causing this condition is thought to be the use of high temperature during incubation of the eggs in order to speed up the development of the subsequent fish (Poppe, 2001).

Disease

Salmon farming has been hit by several well-documented waves of disease that have caused serious losses. These have included Furunculosis, Bacterial Kidney Disease, Vibriosis, and more recently, Infectious Salmon Anaemia. These epidemics have been responsible for the deaths of millions of fish either directly or through slaughter programmes designed to control them.

The Scottish salmon industry believes that the most pressing welfare issue currently is the limited availability of veterinary medicines to treat diseases and other afflictions affecting the fish.

Intensive farming of fish effectively predisposes the animals to disease by rearing them in huge numbers and at very high concentrations. Disease is a serious welfare issue. So too are the intensive conditions under which many farmed fish are kept leading to a greater susceptibility to disease. It is essential that safe and effective medicines are available to treat disease outbreaks. However, these should not be used as a substitute for better systems of husbandry and management with higher levels of welfare potential for the fish.

Mortality

Mortality is one of a range of welfare indicators. High mortality suggests a serious welfare problem. Mortality amongst salmon smolts was found by the Farm Animal Welfare Council (FAWC, 1996) to be "much higher than that in other farmed animals." FAWC called for a reduction in mortality levels through improved management and the development of systems that are "better for fish welfare."

Table 1. Salmon Smolt Survival in Scotland (assumes that escapes are relatively uncommon).

SURVIVAL OF SALMON SMOLTS IN SCOTTISH SEA CAGES						
Year smolts put to sea	Total smolts put to sea (000s)	Number Harvested in same year (000s)	Number Harvested after 1 year (000s)	Number harvested after 2 years (000s)	Total % of year class harvested	% Smolt mortality per year class
1990	21,408	-	8,877	4,315	61.6	38.4
1991	20,227	-	8,864	4,675	66.9	33.1
1992	20,527	-	11,102	5,096	78.9	21.1
1993	20,541	46	13,446	5,135	90.7	9.3
1994	21,953	260	14,420	5,408	91.5	8.5
1995	26,786	206	17,132	6,195	87.9	12.1
1996	32,060	315	20,245	5,148	79.0	21.0
1997	42,766	282	29,014	9,027	89.6	10.4
1998	45,870	696	22,556	8,450	69.1	30.9
1999	41,106	1,000	23,077			
2000	45,185	765				

Source: Adapted from FRS Marine Lab., 2001.

Mortality levels remain high for salmon smolts when compared with other farmed animals, accounting for about 10-30% of juveniles reared at sea (Table 3 above). The

45 million salmon juveniles put to sea in 1998 suffered a shocking mortality rate of about 30%. Disease outbreaks, mortality during sea lice treatment, and losses from plankton blooms associated with poor environment were largely to blame (FRS Marine Lab, 2001). Overall mortality is likely to be even worse when losses from the rest of the farmed salmon life cycle are taken into account. Wall (1999) quotes losses of 10% at the egg to fry stage, and a further 10% from fry to smolt.

Premature fish deaths occur for many reasons including disease, poisoning by toxic algal blooms or hot weather causing oxygen starvation amongst the fish. Mass mortality can occur on intensive fish farms. In 1999, an estimated 240,000 salmon died on one Scottish farm alone. This was apparently caused by overstocking and resulted in 600 tonnes of dead fish (FoE, 2000b).

Mortalities on Norwegian farms in 1997 accounted for an estimated 7,000 tonnes of dead fish. Most of this mortality tonnage is recycled to produce feed for farmed mink, as well as compost and garden fertiliser. In 1993, half a million Scottish salmon were destroyed due to oil pollution. These fish were made into silage for use in the fur farming industry (Willoughby, 1999).

Dead fish are removed from salmon cages in a number of ways, including sending down divers on a weekly basis, the use of remotely operated vehicles or removable 'dead socks' – removable elongated tubes of netting at the bottom of the cage into which dead fish fall.

FAWC (1996) had difficulty in finding mortality levels in farmed trout, but suggested that it is "higher than that which occurs in other farmed animals." Similarly, this study was unable to find mortality data for trout.

Mortality levels in intensive salmon farming remain high throughout the fish' lifecycle. This indicates serious welfare problems. High stocking densities and other key welfare factors should be addressed in order to reduce the otherwise high levels of premature deaths.

Setting a Maximum Stocking Density

The prevalence of fin and tail injuries, blinding cataracts, abnormal behaviours, disease outbreaks and high rates of mortality strongly indicate that current commercial stocking densities for farmed fish are too high. Yet there seems to be a reticence in official circles about setting maximum stocking densities.

It is argued that the increased productivity of intensive fish farming is testimony to good standards of welfare. Because production criteria are met, it does not follow that *quality of life welfare* criteria are necessarily being fulfilled. There are many examples of intensive farming systems that are highly productive, but in which the welfare of the animals is unacceptably low. Battery cages for hens and intensive rearing methods for broiler chickens are but two examples. This is not to draw an analogy between fish farming and these terrestrial systems (although some within industry do), but to point out that the overall welfare requirements of farmed animals goes beyond simply getting the conditions right for productivity.

European fish farmers are currently stocking sea-caged salmon at 15-30 kg/m^3. Trout reared in freshwater are often stocked at 30-40 kg/m^3, but incredibly high densities of 120 kg/m^3 have also been suggested. To properly protect the welfare of fish, a maximum stocking density should be set. FAWC (1996) noted the lack of good scientific information on the effects of stocking densities on welfare. Research has now been commissioned to look at this area. However, the prevalence of fin and tail injuries, blinding cataracts, abnormal behaviours, waves of disease (e.g. Furunculosis and Infectious Salmon Anaemia), and high mortalities strongly indicate that stocking densities must be reduced.

FAWC stated that "high stocking densities must be avoided until it can be demonstrated that they do not have harmful effects on fish." Organic producers of farmed fish have, under their UK interim standards, arrived at maximum permissible stocking densities after consultation with interested parties such as veterinarians and fish farmers. These stipulate stocking density maximums of 10 kg/m^3 for salmon stocked in seawater, and 20 kg/m^3 in freshwater. Freshwater stocking rates for trout are 10-20 kg/m^3 maximum, depending on rearing system. These should provide targets for initial reductions in stocking density enforceable by law across the entire fish farming industry.

This study recommends that maximum stocking densities of 10 kg/m^3 for salmon smolts at sea, and 20 kg/m^3 for trout reared in freshwater should be introduced urgently by legislation on welfare grounds. Further reductions should be considered in the light of future practical and scientific evidence, taking full account of welfare indicators such as abnormal behaviour, injuries, disease, parasitic attack, and mortality.

SEA LICE

The single most important disease problem affecting the welfare of farmed salmon is sea lice infestation. Sea lice are small crustaceans that can weaken and kill affected fish. They feed on the blood and underlying tissues of their host causing skin and scale loss. Lice damage around the head can be so severe that the bone of the living fishes' skull can be exposed – a condition sometimes referred to as the "death crown".

Wild salmon rid themselves of the lice naturally as they drop off when the fish enter freshwater on migration. For farmed salmon, the solution is far less simple. As with any disease problem, prevention is better than cure. A range of treatments exists for sea lice. However, most are questionable on welfare or environmental grounds. They involve bathing the fish in a chemical solution, feeding an oral pesticide or using "cleaner" fish such as wrasse to eat the lice off affected fish.

Bath Treatments

Infested fish are bathed in a chemical nerve toxin, which paralyses the lice. These toxins fall into two main groups; organophosphates and synthetic pyrethroids. The fish are crowded together by hauling up the cage netting before being enclosed in a 'skirt' of tarpaulin. The chemical is then applied. Both of these procedures cause a great deal of stress to the fish. Application of the chemical can cause losses amongst the fish as they can panic and burrow into the corners of the cage (Wall, 1999).

The organophosphates include Dichlorvos (Nuvan), the most commonly used treatment in the 1980's. Dichlorvos is now being phased. This chemical achieved notoriety amongst environmentalists for its devastating effect on marine life. It has now been largely replaced by Azamethiphos (Salmosan).

The synthetic pyrethroid, Cypermethrin (Excis) has proved to be one of the most effective chemical treatments available. However, its application does stress the fish, putting them off their feed for several days. It is reported to be 85% effective against sea lice (Willoughby, 1999).

David Mackay of the Scottish Environmental Protection Agency (SEPA) described some of the chemicals used as "capable of severe environmental damage, especially to crustacea, on a large scale" (Mackay, 1999). Most of the chemicals come within the scope of the EC Dangerous Substances Directive, requiring the setting of emission standards for each site.

The third major type of bath treatment, and the one seen as environmentally friendly, is hydrogen peroxide. This chemical is bubbled through porous pipes into the cage containing crowded fish. Its environmentally friendly credentials stem from hydrogen peroxide breaking down chemically during treatment into water and oxygen. It is neither fully effective nor welfare-friendly. Hydrogen peroxide is a well-known irritant. Fish find it very stressful, and its application can cause significant mortality. As well as causing the fish to suffer, it is also not fully effective at removing lice. It works by stunning the lice rather than killing them. Successful treatment relies on the crowded fish knocking against each other or rubbing against the nets to dislodge the stunned lice. Any lice that are not removed simply recover.

In-Feed Oral Treatments

Newly developed in-feed treatments for sea lice do not entail the crowding or bathing of fish in irritant chemicals, and enables them to treat themselves through feeding without knowing it. The two oral treatments currently available are Emamectin (Slice) and Teflubenzuron (Calicide). Emamectin apparently has no adverse effects on the fish from treatment and it is reasonably long lasting, its effect continuing for 6-7 weeks after treatment.

Environmentally, in-feed treatments can be targeted more closely at the sea lice, and dosing kept to a more effective minimum than bath treatments. But they are not without their problems. Mackay (1999) points out that residues from oral treatments may accumulate in sediments around the cages where they may pose a danger to non-target species of wildlife.

Consumer resistance to in-feed treatments has already been demonstrated. Some retailers refused to accept salmon treated with Ivermectin, a substance administered in food pellets. However, Ivermectin is no longer available for general use on Scottish fish farms, and was originally developed for terrestrial species. The manufacturer did not recommended its use in an aquatic environment. The newly developed in-feed treatments are specially tailored for aquaculture. Their effect on welfare, the environment and product quality will be watched with interest.

Cleaner Fish - Wrasse

Several species of wrasse, small fish that actively eat parasites off other fish, are used as an “environmentally friendly” way of treating sea lice. However, the practice is neither welfare-friendly for the wrasse nor environmentally friendly. In 1996, an estimated 3 million wrasse were taken from the wild for use in Norwegian salmon farms. Some areas have already reported a reduction in wild wrasse populations (Willoughby, 1999).

Wrasse mortality rates of 50% have been reported. Some die from the stress of capture and transport to the farm (Willoughby, 1999). Others die from bullying or being eaten by salmon cage-mates, or through starvation in the winter at the low point of the sea louse life cycle.

Few if any wrasse are being used in Scotland at present. This is partly due to their ineffectiveness, especially for bigger salmon. The wrasse have difficulty keeping up with faster fish for their meal. Another reason was the outbreak of Infectious Salmon Anaemia (ISA), and fears that wrasse could help spread disease. With the apparent disappearance of ISA, wrasse are again being considered by at least some within the Scottish industry. Their use is also permitted within UK organic fish farming standards.

FAWC (1996) recommended that wrasse should be provided with food if sufficient lice were not available, and that they should be removed before the salmon are graded or starved before slaughter. These recommendations seem impractical. They are also inadequate to properly protect the welfare of these wild creatures held captive in an adverse environment.

Wrasse are killed after each production cycle to prevent disease transfer from one salmon batch to another. This makes catching new stocks each year a necessity. Several hatcheries are experimenting with producing wrasse under artificial conditions but they have so far run into technical problems.

Taking large numbers of wrasse out of the wild for use in fish farms where they are subjected to serious threats to their welfare is unacceptable.

Vaccination

Research on a vaccine against sea lice is progressing, although not without difficulties. Work on identifying and manufacturing possible vaccine components has so far required recombinant gene technology (Willoughby, 1999). A vaccine to treat the serious sea lice problem could be a welfare-friendly way forward. However, veterinary products including vaccines should not be used as a means of allowing animals to remain under intensive conditions. The cause of welfare problems – the use of inappropriate systems with low welfare potential – should be tackled as well as the symptoms – increased disease and parasitic infestation.

The fact that genetic engineering techniques are being used as a means of vaccine development is a cause for concern.

General Strategies

Infestation by sea lice continues to be a big problem in the salmon farming industry. It has been described as a "husbandry disease brought about by inappropriate husbandry practices". Most Scottish salmon farmers are currently using bath treatments for sea lice. This is due to difficulties getting the necessary permission, or discharge consent, from the Scottish Environment Protection Agency (SEPA) to use the new oral treatments on farm and thereby in the environment.

Anti-sea lice measures taken so far are reported to have had an impact on the parasite, especially in vulnerable young fish. Positive measures include periodic fallowing of cage sites and the setting up of complimentary management procedures between farms sharing the same tidal zones. This includes treating neighbouring sites at the same time to avoid cross-contamination and increase the effectiveness of treatments. A coordinated industry-wide assault on sea lice has been set up whereby all salmon will be treated at the same time during the winter. The aim is to reduce lice populations across the board.

A big problem in the battle against sea lice is that the parasite can develop resistance to specific treatments. The importance of having several treatments available for rotation was stressed by industry during this study. This is to avoid effective treatments being rendered obsolete. However, the best long-term strategy is continued improvements in husbandry and management, including the careful selection of sites to minimise susceptibility to sea lice.

Sea lice infestation is a serious welfare problem in farmed salmon. If untreated, it can lead to fish suffering considerably and dying. Wherever possible, it should be controlled by improved husbandry and management including careful site selection. Sites should have clean, fast-flowing water to reduce the likelihood of serious parasitic attack.

Intensive farming has led to sea lice becoming the greatest single problem for farmed salmon in many areas. Current treatments centre on the use of strong nerve toxins that have possible environmental effects. More 'environmentally-friendly' methods; hydrogen peroxide and the use of wrasse as "cleaner" fish have serious animal welfare drawbacks. Hydrogen peroxide is not acceptable on welfare grounds as its application is highly aversive to the fish and can cause mortalities. The use of "cleaner" fish is not acceptable as wild-caught wrasse suffer high mortalities in salmon cages due to starvation, bullying and being eaten by larger salmon.

> "The greatest single problem for the Scottish salmon farming industry is sea lice"
>
> "In Norway, the sea louse situation has continued to become more severe, especially since 1995. Many areas previously considered lice-free…have reported heavy infestation for the first time."
>
> (Manual of Salmonid Farming, Willoughby, 1999)

OTHER MANAGEMENT PROCEDURES

GRADING

Fish grow at varying rates. Under confined conditions, larger fish may bully smaller ones, or even cannibalise each other. To minimise this, farmed fish are periodically sorted or 'graded' into different sizes. This involves netting or pumping them out of the water and over a series of bars, with smaller ones falling through the slats.

Little work appears to have been done to evaluate the welfare aspects of the various grading methods. For example, vacuum pumping or airlift methods keep the fish in water all the time without the need to handle them with potentially damaging nets. But to what extent do the fish suffer from the inevitable pressure gradients in this system? Also, to what extent do the different methods cause the fish to lose scales or cause other physical problems?

The fish need to be crowded before pumping, which is stressful to the fish. Whatever procedures are used, handling of the fish needs to be minimised. It appears that under normal circumstances, problems at grading usually relate to the crowding of fish, and the length of time for which they are crowded.

Grading is a stressful management procedure for fish. Comparative work needs to be carried out to assess the welfare aspects of the different grading methods using non-invasive techniques. This work should compare the stressor effects of the different grading systems, looking at physical damage such as scale loss and abrasions, the length of time fish go off their feed, and the post-grading 'growth check' – the drop in growth rate in the days immediately after grading.

TRANSPORT

There are three main methods used to transport farmed fish, especially salmon; well-boats, helicopters or in tanks on the back of flat-bed lorries.

Well Boats

Well-boats allow fish to be moved in a boat that contains a pool of seawater within its hull. The fish are kept in this pool, and the water is refreshed by continually pumping water through the hull of the boat. The water in the well boat is therefore not static, unlike during transfer by helicopter bucket or lorry-borne tank.

Helicopter & Bucket

This method is used principally to move salmon smolts over short distances. Very high numbers of fish are crowded in a small volume of highly oxygenated water (twice the volume of water to fish) and carried in a purpose-built tank or 'bucket' slung underneath a helicopter. When they have reached their destination, the fish are "poured out" into sea cages or a waiting well boat.

Lorries

A tank carried on the back of flat bed lorries is another common method of transporting live fish. The vast majority of the trout transported in the UK travel this way. Although lorries take much longer to cover the same distance as helicopters, they are less stressful to the fish and therefore better for longer journeys than helicopters.

Fish are usually starved for 48 hours before transport. This is to reduce faecal contamination of the water. It also reduces the amount of oxygen that the fish need when they are crowded together in a small amount of water for the journey.

Movement and transfer of fish, especially smolts, is an area of potential welfare concern. It is likely to be a frightening experience for fish and has been described as causing them "considerable" stress (Shepherd & Bromage, 1988). To protect fish welfare, transport times should be reduced to the absolute minimum. Water conditions such as oxygen levels, carbon dioxide, and pH should be monitored at frequent intervals.

PREDATORS AND PREDATOR ATTACK

There can be few more stressful encounters for confined fish than a seal or other predator lunging through the cage netting and taking a bite. There are, however, a variety of ways of preventing wildlife such as seals, birds, mink and otters from taking advantage of a free meal without resorting to the 'wild west' mentality of shooting them. Methods include sonic and visual scarers, and nets to exclude predators from tanks and cages. Top nets to protect the water surface from birds and side and base nets (which enclose the cages in a box or curtain of net) are used to exclude predators from most if not all fish farms.

Poorly fitted nets can lead to wild animals including birds reaching the fish. They may also become entangled and drown. Using smaller mesh sizes and ensuring they are properly tensioned and weighted down more heavily can avoid tangling.

Some fish farmers have seen the killing of wild animals as a legitimate part of predator control (Ross, 1988). Animals have been chased by boats in an attempt to drive them away. Any that fail to get the message are shot. Seal shooting by fish farmers is still believed to be widespread. In Scotland, an estimated average of 10 seals per fish farm site are killed each year (Robins, pers comm.). With nearly 350 farms now in Scotland, the impact of Scottish salmon farming could be as high as 3,500 seals killed each year.

The real price of farmed salmon includes the killing of an estimated 3,500 seals around Scottish fish farms each year. This appalling destruction of wildlife is unacceptable. Wildlife should not be shot or otherwise harmed as an anti-predator measure.

CIWF Trust believes that every precaution should be taken to avoid predators gaining access to the stock through the use of anti-predator nets and other non-lethal deterrents.

UK Intensive Aquaculture - Salmon

Max. stocking density (freshwater):	30-50 kg fish per m^3 water
Max. stocking density (Sea water rearing):	15-20 kg fish/m^3 water (Scotland) 25-30 kg fish/m^3 water (Norway)
Sea lice control methods:	Range of organophosphate, pyrethroid & Hydrogen peroxide bath treatments, in-feed treatments and cleaner fish.
Colorants used:	Canthaxanthin and/or astaxanthin
Starvation period before slaughter:	7 days (minimum)
Slaughter method:	Percussive stunning + gill cutting, or stunning in carbon dioxide
Labelling terms:	No specific terms

Prohibited: Scottish Quality Salmon believe that genetically engineered fish are unacceptable.

UK Intensive Aquaculture – Trout

Stocking density:	20-110 kg fish per m^3 water
Colorants used:	Canthaxanthin and/or astaxanthin
Starvation period before slaughter:	Up to 7 days
Slaughter method:	Suffocation in air/on ice, carbon dioxide stunning.
Labelling terms:	No specific terms

Widely Used: Biotechnology to produce sex reversal and triploid stocks.

SEX REVERSAL, STERILISATION & GENETIC ENGINEERING

Genetic engineering techniques are being developed for aquaculture. These threaten to push back the boundaries of intensification and cause yet more suffering for farmed fish. Researchers are working on fish that grow larger and faster, convert feed into flesh more efficiently, and are resistant to disease, tolerant of low levels of oxygen in the water, and can stand freezing temperatures. Dramatic increases in growth rates have already been achieved experimentally. Transgenic salmonids with additional fish growth hormone genes have shown up to 11-fold increases in weight within a year of growth (Dunham & Devlin, 1999). In the UK, in 1998, there were 2,609 licensed experiments involving genetic modification of fish.

Two main techniques are being used to genetically engineer fish; microinjection, in which genetic material is injected into newly fertilized fish eggs; and electroporation, whereby genetic material (DNA) is transferred into fish embryos using an electric current.

Already, health and welfare problems are being noted. Excessive cartilage deposition has been reported in transgenic salmonids. This has resulted in affected individuals suffering feeding and breathing difficulties and poor viability (Dunham & Devlin, 1999).

Growth hormone genes from human or animal sources have been introduced into several fish species to speed up growth rates. US/Canadian company, A/F Protein inc. has developed a genetically engineered version of the Atlantic salmon (Salmo salar), for commercial use. This species is the one widely farmed in Europe. The genetically modified version contains a growth hormone gene from Chinook salmon and grows 4-6 times faster than ordinary salmon (Aken, 2000). According to Aken (2000), nearly 100,000 transgenic salmon and trout are held in Canadian fish tanks, and the first transgenic fish could be available in supermarkets as early as 2002.

Britain has not been free from transgenic dabbling, albeit temporarily so far. In 1996, genetically modified salmon were grown for a year before being destroyed at a Scottish land-based containment facility (FoE Scotland, 2000a).

Transgenic Escapes

Escapes from fish farms have become a fact of life for the modern industry. Farm escapes are already implicated in the decline of wild salmon stocks. In Maine in the USA, for example, a major reason for declines in wild stocks is seen as genetic dilution of wild Atlantic salmon populations by farm-raised fish, that have trouble finding their way back to local streams to spawn (Niiler, 2000). Transgenic escapees threaten to have an even worse effect.

New research funded by the US Food and Drug Administration shows that introduction of transgenic fish into the wild could lead to rapid extinction. The study used genetically modified Japanese medaka fish (Oruzias latipes) as a model. The GM fish produced human growth hormone and matured faster with more eggs than non-GM relatives. The GM males had four times more opportunities to mate because of their larger size compared with non-GM males. However, the offspring showed a higher rate of mortality (30%) before reaching maturity. The study concluded that "a transgene introduced into a natural population by a small number of transgenic fish will spread as a result of enhanced mating advantage, but the reduced viability of offspring will cause eventual local extinction of both populations" (Muir & Howard, 1999). As few as 60 transgenic fish could lead to the extinction of a population of 60,000 fish in 40 generations.

Industry Condemnation

The prospect of transgenic salmon eggs being licensed for commercial use by the US Food and Drug Administration prompted several industry bodies to declare resistance to the technology. Scottish Quality Salmon (SQS) said that its members were "totally opposed to the use and marketing of any such products." The International Salmon Farmers Association also rejected the use of transgenic salmon (SQS, 2000). These moves are highly welcome. However, it remains to be seen how strong industry opposition remains if transgenic salmon are used commercially by global competitors.

Transgenic Fish & Future Welfare

There are, of course, moral and human safety issues surrounding genetic engineering. There are also grave concerns for the welfare of genetically engineered animals themselves. Modern intensive farming methods already push animals toward their physiological limits or rear them under conditions that can harm their welfare. In terrestrial farming, for example, broiler chickens reared for meat are packed in their thousands into windowless sheds. They grow so fast that painful crippling is common and losses through heart failure in 6-week-old birds are expected.

Transgenic farm animal production threatens to open up a whole new array of welfare problems. Genetically reconstructing animals for higher performance is one route to greater intensification. The other is by inferring genetic resistance to disease, and thereby conquering nature's inbuilt limitation on how intensively farmers can keep farm animals and get away with it. Normally, when large numbers of animals are kept in overcrowded conditions they suffer stress, which lowers their immune system, making them susceptible to disease. Farmers are to some degree limited in how intensively they can farm through fear of paying the price in dead and diseased stock. Genetically engineered disease resistance could remove this natural break and lead to animals being kept in even more stressful, poor-welfare conditions. Of course, no one wants animals to suffer disease. However, transgenic disease resistance should not be used as a way of enabling the use of systems that further compromise the welfare of the animals involved.

Fish, in common with other farm animals, are sentient beings that can experience suffering. Genetic engineering should not be used to further relegate them to the status of 'animal machines' (Harrison, 1964).

SEX REVERSAL AND TRIPLOID FISH

Biotechnology is already used in European farmed fish to produce all-female stock and triploid fish that have an extra set of chromosomes to induce sterility. These practices are widely used in the trout farming industry to manipulate the chromosomes of fish reared for slaughter.

All-Female Fish

Sex reversal is used to produce batches of all-female fish that will mature later than their male counterparts. This is desirable to the industry as sexually mature fish undergo changes that can reduce flesh quality.

The process involves feeding the male sex hormone, testosterone, to young female fish (containing two X chromosomes). This converts them into functional males. Sperm from the resulting 'males' is then used to fertilise eggs from normal females. However, because the hormone-induced 'males' are actually *genetic females*, all their sperm will contain only X chromosomes. As none of the sperm contained male-conferring Y-chromosomes, the resulting offspring will be all females.

Hormone treatment is used on the broodstock only. The offspring reared for human consumption will not have been hormone treated. More than 26 million trout ova were produced in England and Wales during 1999/2000 (CEFAS, 2000a).

Triploid Fish

Nearly 5 million triploid trout eggs were produced during 1999/2000 in England and Wales (CEFAS, 2000a). In 1993, more than 4,000 tonnes of triploid salmon were produced in Britain provoking criticism from consumer groups due to lack of labelling (Willoughby 1999).

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 before slaughter, show increased feed efficiency, and any that escape will not endanger wild populations by inter-breeding. Using triploidy to produce sterile fish has therefore been advocated as a means of preventing sea cage escapees from disrupting wild salmon gene pools.

Table 2

OVA PRODUCTION FROM SITES HOLDING BROODSTOCK SALMONIDS IN ENGLAND & WALES 1999/2000						
Rainbow Trout			Brown Trout			Salmon
All Females (000s)	Mixed Sex (000s)	Triploid (000s)	All Females (000s)	Mixed Sex (000s)	Triploid (000s)	Mixed Sex (000s)
26,343	6,018	4,898	368	8,681	504	954

Source: CEFAS, 2000a

In its welfare report to Government, the UK Farm Animal Welfare Council (FAWC, 1999) described the genetic engineering of fish by chromosome manipulation to produce triploid individuals as having "no obvious welfare implications." The available evidence shows otherwise.

Whilst the process itself may not have welfare effects on the fertilised eggs, it does have consequences for the health and welfare of the growing fish. Higher levels of spinal deformities have been found in triploid Rainbow trout compared with diploids (Madsen et al, 2000). Triploid salmon have been found to have significantly lower survival rates than diploids in a similar situation (Johnstone, 1992). Studies reviewed by Willoughby (1999) suggest that triploid salmon are less able to absorb oxygen, leaving them less able to cope with stressful situations. This could be a particular problem when fish are crowded together for management procedures such as grading, transport and treatment for sea lice. Triploid salmon populations in Scotland have an increased tendency to suffer mortalities during sea lice treatment (Johnstone, 1992). They also show higher mortality levels in less oxygenated water when infected with bacterial gill disease. Triploid fish can also be anaemic, showing lower blood haemoglobin levels. Changes in the surfacing behaviour of triploid salmon have also been noticed (Willoughby, 1999). In 1991, batches of triploid salmon were found suffering from eye cataracts causing blindness, whilst equivalent batches of diploid salmon remained free from the condition (Wall & Richards, 1992).

Triploid fish, as well as transgenic fish and sex-reversed stock are not permitted under the interim UK organic farming standards for fish.

The production of triploid fish is widely used in the UK trout industry. It has been found to cause a range of health and welfare problems in the affected fish. Biotechnology techniques involving chromosome manipulation (e.g. sex reversal and triploidy) should be prohibited.

Genetic engineering using transgenic methods not only threatens to increase the suffering of farmed fish through greater intensification, but the process itself has already been found to cause welfare problems. Fish, in common with other farm animals, are sentient beings that can experience suffering. Genetic engineering should not be used to further relegate them to the status of animal machines. The use of genetic engineered fish for farming should be prohibited.

SLAUGHTER OF FARMED FISH

About 70 million fish are produced and slaughtered on British farms each year. In terms of the number of animals killed, farmed fish represent the second largest livestock sector in the UK after broiler chickens. More farmed fish are slaughtered annually than all the pigs, sheep, cattle and turkeys put together. Yet farmed fish have so far received second-class attention from legislators. Some legally allowed slaughter methods cause intolerable suffering from a stressful and prolonged death. So much so that the perpetrators would be prosecuted if they were slaughtering other farm animals in a similar way.

Key recommendations by the Government's advisory body on welfare have still not been implemented. In its 1996 Report on the Welfare of Farmed Fish, the Farm Animal Welfare Council (FAWC) described the killing of trout by suffocation in air as "not acceptable". It recommended that killing trout through suffocation on ice should be prohibited. Five years later, these methods continue to be the most widely used by the UK trout farming industry.

Legislation

In Britain, the slaughter of farmed fish is covered under The Welfare of Animals (Slaughter or Killing) Regulations 1995. The general provisions of the Regulations make it an offence for any person engaged in the movement, restraint, stunning, slaughter or killing of fish to cause any, or permit any, fish to sustain any "avoidable excitement, pain or suffering". The specific requirements that cover the stunning of animals does not apply to farmed fish. In its 1996 Report, FAWC stated that:

> "the three basic principles in those provisions should apply equally to fish. These are that stunning must cause immediate loss of consciousness which lasts until death, that fish must not be stunned unless they can be bled or otherwise killed without delay and, if fish are to be killed without prior stunning, any method used must result in rapid and irreversible loss of consciousness. In this context the relevant aspect of consciousness is sensibility to pain, fear or distress."

To stop the suffering of farmed fish at slaughter, the only methods that should be permitted are those that cause an instant death or render the fish instantly insensible to pain until dead. A variety of slaughter methods are used depending on the species being 'harvested'. Sadly, these often fall well short of this welfare criterion and cause prolonged suffering. The main methods are set out below.

SALMON SLAUGHTER METHODS

Percussive stunning by blow to the head

This is carried out manually using a hand-held club known as a 'priest'. If sufficient force is applied accurately, unconsciousness can be immediate and irrecoverable. Cutting the gill arches is then performed to bleed the fish. This ensures that the fish will not recover from the stun and helps maintain flesh quality.

This method is gaining acceptance by salmon farmers. Mobile teams of workers are killing batches of 3,000-5,000 salmon percussively in a session. Great care is needed to ensure that worker fatigue does not lead to inaccurate or ineffective stunning.

Mechanical stunners are being developed which deliver a uniform and accurate percussive stun. One such device is the pneumatic Salmo Humane Slaughtering Machine. The fish are taken out of the water and an operator feeds a salmon into the machine. The fish sets off an air bag clamp that holds it firmly. A stunning hammer delivers the stunning blow before an automatic blade cuts the fish to drain the blood. Some within the Scottish industry are already looking at this system as a possible welfare advance over manual stunning. If successfully developed, this type of device would greatly reduce the scope for 'bad hits' that cause suffering at slaughter.

Carbon dioxide stunning

A significant proportion of the Scottish salmon industry uses carbon dioxide as a stunning method. Fish are placed in a seawater bath saturated with carbon dioxide. This environment is highly aversive with fish being observed to shake their heads and tails vigorously trying to escape (Robb, et. al., 2000). Movement ceases after 30 seconds, but sensibility may not be lost for 4-5 minutes (Robb et al, 1997). In other words, the fish can still feel what is happening to them long after they have become immobile. A more recent study suggests that unconsciousness can take even longer – up to 9 minutes or more (Robb et. al., 2000).

Bleeding after carbon dioxide stunning is essential to avoid the fish recovering. A real fear is that if fish are removed early from the stunning tank, they are likely to have their gills cut when immobile but still conscious. Because carbon dioxide causes the fish to become immobile well before they are insensible, this method will cause great suffering, especially if the immobile but still conscious fish are cut severely and allowed to bleed to death.

Carbon dioxide stunning is widely used commercially. In Norway, some of the salmon stunned by this method are gutted immediately rather than being bled by gill cutting (Horrex, 1999).

Carbon dioxide stunning can cause great suffering to fish at slaughter and should be prohibited.

Bleeding without prior stunning

This method is still thought to be used by some in the UK, although not widely. The gill arches are cut with a knife and the fish bleed to death. After gill cutting, the fully conscious fish react vigorously, and cease moving after 4-7 minutes (Wall, 1999; Robb et al, 2000). This method should be prohibited urgently.

TROUT SLAUGHTER METHODS

Electrocution

Electric current is passed through the water containing the fish. The electric current must be sufficient to stun and kill the fish otherwise considerable suffering could result. This is because trout are not generally bled after stunning, a precaution otherwise necessary to prevent the fish recovering consciousness. There is also a danger that if the current is inadequate, the fish are paralysed and could suffer considerably before ultimately dying. The industry has been slow to take up this method as it can cause spinal fractures and haemorrhaging that reduce carcase quality.

Research into the use of high frequency currents for trout stunning have shown promising results (Robb et al, 2000b), generating fewer haemorrhages than normal commercial slaughter methods. Silsoe Research Institute is developing a machine that will allow fish to be continuously pumped from the pond into a rotating stunning chamber. Here the trout will be electrically stunned for 2 minutes, which should ensure that the fish are killed by the procedure.

Electrical stunning is used on a limited basis in the UK, mostly by small-scale trout farms. Fish slaughtered electrically need to be well graded as the effect of the stun can be different dependent on the size of the fish.

Electric stunning is potentially a relatively humane killing method for trout. However, an adequate electric current must be used to stun and kill the fish, otherwise the fish could suffer greatly.

Asphyxiation in air or on ice

This method involves simply hauling the fish out of water or draining water away and allowing them to die through suffocation in air. The Government's advisory Farm Animal Welfare Council (FAWC) (1996) stated that "the widely used method of leaving the animals to suffocate in air is not acceptable. This situation, and the need for control by legislation should be reviewed in the near future."

Alternatively, trout are removed from water into bins containing ice. This helps to promote the shelf life of the fish. It also prolongs the suffering of the dying fish. The cooling effect of the ice can prolong the time to unconsciousness. Research has shown that fish 'harvested' in this way can still feel what is happening to them almost 15 minutes after being taken out of the water (Kestin et al, 1991). It was concluded that this practice could unnecessarily prolong the time to unconsciousness. FAWC (1996) recommended that "cooling of live trout on ice after they have been removed from the water should be prohibited." Despite this however, killing through suffocation on ice remains "very commonly" used in the British trout industry (Robb, 2000c).

Both methods of allowing fish to suffocate, in air or on ice, cause immense suffering to fish and simply would not be tolerated as slaughter methods for terrestrial farm animals. Slaughter by suffocation should be prohibited urgently.

Carbon dioxide stunning

As mentioned for salmon, stunning with carbon dioxide is slow to produce unconsciousness, and highly aversive to the fish which thrash around the killing container. This stunning method needs the fish to be bled to avoid recovery, something not generally practiced on smaller "portion" sized trout.

Researchers from the University of Bristol and Silsoe Research Institute assessed the relative welfare-friendly nature of ten trout slaughter methods. These were based on both commercial and research procedures. They ranked the ten slaughter methods with respect to welfare and quality, with 1 indicating the best, and 10 the worst. Expert assessors from Bristol University carried out measurements of welfare. Representatives from retail, industry and animal welfare assessed the *perceived* welfare and quality of each method. The results are shown in table 3 below.

RANKING OF TROUT SLAUGHTER METHODS WITH RESPECT TO WELFARE AND QUALITY			
Slaughter Method	**Perceived Welfare**	**Measured Welfare**	**Perceived Quality**
Death in Air	10	10	3
Death on Ice	7	9	6
Carbon dioxide	9	8	4
Carbon dioxide + Ice	7	7	7
AQUI-S + Iki jime (spiking)	3	1	1
Percussive Stun	2	1	4
Iki jime (spiking)	6	1	2
Head Only Electric Stun	5	1	8
Whole Body Electric Stun (short)	4	6	10
Whole Body Electric Stun (long)	1	1	9
Ranking of 1 indicates the best and ranking of 10 the worst			

Table 3. Source: Adapted from Robb, Kestin & Lines, 2000. In: Fish Farmer, Nov/Dec 2000

From this investigation, it is clear that slow killing methods (such as suffocation in air or on ice) were "unacceptable" in terms of fish welfare, tending to "induce great stress." Electrical stunning methods to stun and kill the fish were classed among the best on welfare, but scored less favourably on quality. This is due to haemorrhaging and broken spinal columns. Further work is being carried out at Silsoe, as mentioned above, to overcome these perceived quality problems.

Accurate percussive stunning seems to offer a relatively welfare-friendly method of killing fish. These include the Iki jime method of inserting a spike manually into the brain and rotating to destroy it, a method not widely used in the UK. However, percussive stunning is seen as less practical for large numbers of smaller fish such as 'portion-sized' trout.

One consideration when developing better welfare systems is that taking fish out of their element – water – however briefly is likely to cause stress. Therefore, an 'ideal' slaughter method would probably involve the killing of fish without removal from water. Carbon dioxide saturated water is known to be highly aversive to fish. The use of alternative inert gases for stunning might achieve less stressful results.

To protect the welfare of farmed fish at slaughter, legislation should be introduced that gives equal protection to farmed fish as to other farm animals. Methods that do not reasonably ensure an instantaneous death or do not render the animals instantaneously unconscious until dead should be prohibited.

Some widely used slaughter methods for farmed fish cause great suffering. These include suffocating fish in air or on ice, bleeding to death without pre-stunning, and the use of carbon dioxide for stunning. These cause a prolonged time to unconsciousness or death, and are totally unacceptable on welfare grounds. These slaughter methods should be prohibited urgently.

To minimise the suffering of farmed fish at slaughter, only methods that cause an instant death or render the fish instantly insensible to pain until dead should be permitted. These include percussive stunning techniques and electrocution where properly designed and effectively carried out. In the case of electrocution methods, the electric current must be sufficient to stun and kill the fish, otherwise considerable suffering could result.

Pre-Slaughter Handling

The stress of slaughter can start well before the fish reach the stunner. Salmon can have difficulty in adapting quickly enough to being hauled to the surface of deep cages. Cages can be 5m to 20m deep. Fish at a depth of 20 metres experience 3 times the atmospheric pressure at the surface. When a fish is brought to the surface, it must regulate its swim bladder. This can be difficult as Willoughby (1999) reports, “the fish tries actively to swim downwards in a natural escape reaction…to escape the noise, light and activity at the surface. With the head pointing down, releasing excess air becomes even more difficult for the fish. The end result is fish which are highly stressed and exhausted.”

PRE-SLAUGHTER STARVING OF FISH

Farmed fish are normally starved for about 7-10 days before slaughter to empty the gut and minimise the risk of the flesh becoming contaminated when gutted. The starvation period can be extended to 12-14 days in the winter. Scottish Quality Salmon currently insist that its scheme’s producers starve fish before slaughter for a minimum of 7 days.

Farmed fish are conditioned over months and years to expect frequent and plentiful feed. To suddenly cut off that feed is highly likely to be detrimental to their welfare.

Some argue that salmon and trout commonly survive long periods of food deprivation in the wild. During periods of winter scarcity, for example, or when migrating back to freshwater to spawn. Therefore prolonged starvation is said to have no significant impact on fish welfare. The argument goes that salmonid fish are physiologically adapted to build up reserves in times of plenty and then use them in times of adversity.

These arguments are unconvincing on a number of counts. Firstly, good welfare is not just about making sure that fish survive and continue to be productive. High welfare encompasses those non-production/survival aspects that go to make up a state of overall well-being – the 'quality of life' aspects of welfare. The fact that fish survive starvation far from guarantees that their welfare is being protected. Secondly, salmon in sea cages are generally harvested before they are sexually mature and so comparisons with their voluntary fast on migration to spawn do not apply. They are 'harvested' at a point in their lifecycle when salmon would not voluntarily undertake such drastic self-deprivation.

Although dependent on temperature, it takes 24-72 hours to achieve gut clearance in farmed fish (Kestin, pers comm.; Erikson, 2000). The Farm Animal Welfare Council recommended that periods in which fish are "deprived of food prior to certain management procedures or slaughter must be kept to a minimum and should not normally exceed" 48 hours for trout and 72 hours for salmon (FAWC, 1996).

Starvation periods longer than 48-72 hours for farmed fish prior to slaughter are excessive and are highly likely to be detrimental to the welfare of the fish. In addition, prolonged periods of starvation appear to have no demonstrable benefit to 'product quality'. Starvation periods of longer than 72 hours should not be permitted.

THE ROLE OF RETAILERS

A recent survey of the UK's top-10 biggest retailers found that most supermarket trout and some salmon were slaughtered using methods that are totally unacceptable on welfare grounds. Suffocation in air or on ice, both methods that cause a prolonged time to unconsciousness, are widely used killing methods for trout sold in supermarkets. Some salmon destined for major multiples are still stunned using carbon dioxide before having their gills cut, another method condemned on welfare grounds.

The same survey found that salmon on sale in supermarkets have often been starved for 7-14 days before slaughter. This is carried out to empty the fishes' gut and minimise the risk of flesh contamination during gutting. However, experts suggest that only 24-72 hours of starvation is needed to achieve gut clearance. Supermarkets found to be bucking the trend on prolonged starvation periods are Safeway (3 days) and Waitrose (1-2 days).

Most standard sea cage-reared salmon on sale in supermarkets will be kept at a maximum stocking density of 15-20 kg of fish per cubic metre of water. That is equivalent to each salmon measuring three quarters of a metre long (2.5 feet) being allocated a bathtub of water. As the table below shows, some are likely to be crammed even more tightly into their sea cage. Freshwater-reared standard trout are generally kept at maximum densities of 30 kg fish/m^3 of water, but some can be kept at double this density.

Supermarkets have enormous influence over the animal welfare standards used to produce the fish they sell. They dominate the British shopping scene with the 10 biggest supermarket companies accounting for over 60% of all UK grocery sales. The power of the major retailers means they can move quickly and decisively on food standards issues including welfare.

CIWF Trust calls on those supermarkets selling farmed fish to raise their standards of welfare by demanding that suppliers rear fish at much reduced stocking densities, use only humane slaughter methods, and stop the practice of prolonged pre-slaughter starvation.

Table 4.

REARING & SLAUGHTER METHODS OF SUPERMARKET FARMED SALMON - 2001					
	% Total Sales Volume Slaughtered Using Each Method			Welfare Policy	
Company	CO_2 + gill cutting	Percussive Stunning (manual)	Percussive Stunning (Mechanical)	Days Starved before Slaughter?	Max. Stocking Density (Sea water) Kg fish/m^3 water
ASDA	0	100	0	7	20
CWS	20	80		7	20
Iceland Foods	?	?	?	?	?
Marks & Spencer	0	95	5	7-14	20
Safeway*	5	95	0	3	15
Sainsbury's	15	65	20	Scottish: 7 Norwegian: 7-14	30
Somerfield*	0	100	0	7-14	20
Tesco**	54	24	22	7-14	25 (mostly 20)
Waitrose	0	100	0	1-2	Standard 20 Organic 10
Wm Morrison	15	65	20	7	20

Data collected directly from companies by CIWF via questionnaire, July-November 2001
*Data refers to own label product only
**Slaughter method data refers to fresh farmed salmon for Tesco

Table 5

REARING & SLAUGHTER METHODS OF SUPERMARKET FARMED TROUT - 2001						
	% Total Sales Volume Slaughtered Using Each Method					Welfare Policy
Company	Suffocation on Ice	Suffocation in Air	CO_2 Stunning	Percussive Stunning (Manual)	Electrocution	Max. Stocking Density (Kg fish/m^3 water)
ASDA	99	0	0	0	1	Variable
CWS	0	100 (Standard)	0	0	100 (Organic)	30 (Organic 20)
Iceland Foods	?	?	?	?	?	?
Marks & Spencer	100	0	0	0	0	None Set
Safeway*	100	0	0	0	0	30
Sainsbury's	Estimate c100	0	0	0	0	60
Somerfield*	0	90	0	0	10	30
Tesco	**85	0	15	0	0	Freshwater >65
Waitrose	0	0	80	0	20	Standard 29 Organic 10
Wm Morrison	80	18	0	1	1	35-50

Data collected directly from companies by CIWF via questionnaire, July-November 2001
*Data refers to own label product only
**Stunned using ice and salt slurry

FISH FEED, COLORANTS & SUSTAINABILITY

To the consumer, the colour of the flesh is second only to freshness in the fish quality scale (Buttle, 2001). Wild salmon and trout naturally eat crustaceans and algae that give their flesh a healthy pink colour. To achieve this complexion in farmed fish, colorants are added. Otherwise the flesh would appear an unappetising grey colour. Synthetic pigments, canthaxanthin and astaxanthin, are used, either individually or as a mixture of both. Organic salmon and trout have shrimp shell added to their diet.

Salmon and trout are natural carnivores. On the farm, they are fed compound feeds based primarily on fish meal and fish oil. The fish meal is obtained partly from catching so-called industrial species of small ocean-going fish from the waters of South America and Europe. These are said to have little or no demand for human consumption and are known as "trash fish". These include anchovies and sardines from Chile and Peru, and sandeels, capelin and Norway pout from Europe. The trimmings of fish caught for direct human consumption are also used (FIN, 2000).

Pressure on Wild Fish Stocks

It is often claimed that fish farming may take the pressure off stocks of wild-caught fish by providing an alternative. However, for carnivorous species that rely on a high degree of fish in their diet the reverse can be true. Over 3 tonnes of wild-caught fish are needed to produce 1 tonne of farmed salmon. It also takes nearly 2.5 tonnes of wild fish to produce 1 tonne of trout. For marine species such as halibut and cod, both now firmly within the sights of commercial fish farmers, it can take over 5 times the weight in wild fish to produce a farmed fish. Whilst the fish farming industry continues to grow rapidly in Europe and worldwide, stocks of wild-caught fish used for feed remain finite, with a number of them already classified as fully exploited, overexploited or depleted (Naylor et al, 2000).

Feeding wild fish to farmed fish puts wild fisheries under pressure. This is because in common with other animal production systems, farmed salmon and trout do not produce protein – they waste it. Fish may be less wasteful at converting feed into flesh than pigs or cattle, but they are still wasteful.

The Real Rate of Feed Conversion

The fish farming industry quotes fish feed conversion ratios (FCRs) in terms of units of food used per unit of fish produced. FCRs of between 1:1 and 2:1 are talked about. But what do these really mean? It is important to recognise that an 'FCR' compares the weight of food used, which tends to be relatively *dry* processed feed, with the resulting weight gained in *wet* fish.

An FCR of 1:1 sounds impressive, and indeed is compared with other land-based farmed species. However, to the average non-specialist, it implies that fish use food for nothing else but growing flesh. It suggests they use no energy, don't defecate and have no inedible parts. This is impossible. FCRs must be seen for what they are; industry shorthand that fails to reflect the fact that a large proportion of the finished fish's weight will include body water and inedible parts such as bones and guts. By recalculating the FCR, taking these into account, a more realistic food conversion ratio is arrived at. For farmed fish, the real conversion ratio of dry feed to edible flesh matter is between 5:1 and 10:1 (Lymbery, 1992).

Research has been carried out to develop substitutes for fish meal and fish oil as feed ingredients for aquaculture. Within the salmon industry, there has already been a reduction in the fish meal content of diets (Naylor et al, 2000) with further reductions from 40% to 30% predicted over the next ten years (Pike & Barlow, 1999). However, the complete replacement of these ingredients for salmon and other carnivorous fish faces severe difficulties. Attempts to substitute cheaper and unnatural vegetable protein ingredients have, in some cases, compromised the fish immune system (Pike, in litt.). Vegetable proteins have inappropriate amino-acid balance and poor digestibility for carnivorous fish (Naylor et al, 2000). Genetic engineers are trying to jump on the environmental bandwagon. By developing new genetically engineered feed enzymes and plant-based protein sources for fish feed, researchers profess to be helping make fish farming an "environmentally sound and sustainable farming operation" (Agbiotech Infosource, 1998).

The farming of carnivorous fish such as salmon, trout, halibut and cod adds to the pressure on wild fish stocks and is environmentally unsustainable. Over 3 tonnes of wild-caught fish are needed to produce 1 tonne of farmed salmon. It also takes nearly 2.5 tonnes of wild fish to produce 1 tonne of trout. For marine species such as halibut and cod, the ratio is over 5 times the weight of wild fish to produce an amount of farmed fish. In view of this, the sustainability of intensive fish farming should be reviewed.

ENVIRONMENTAL IMPACTS OF INTENSIVE FISH FARMING

Intensive salmon farming has caused a great deal of controversy over its effects on the environment. Long-term environmental impacts are often good indicators of an over-intensive farming system likely to cause welfare concern.

Keeping large numbers of fish concentrated in a small area has led to the pollution of the surrounding environment. Fish wastes, excess feed and chemicals used in husbandry all contribute to pollution of the water.

Habitat Degradation

Solid waste produced from fish faeces and excess feed can settle beneath the salmon cage and surrounding area. This sediment then kills underlying marine life on the seabed, and can affect the composition of species at considerable distances from the cage site. The sediment decays causing partial deoxygenation of the water and the release of damaging compounds such as phosphates, hydrogen sulphide and methane into the water. An increase of soluble wastes in the water, such as levels of nitrates, phosphates and other nitrogenous chemicals can predispose the area to toxic algal blooms.

For each tonne of salmon produced, an estimated 100 kg of nitrogenous compounds, such as ammonia, are released into the aquatic environment. Scotland's fish farm industry produced an estimated 7,500 tonnes of nitrogen in 2000, comparable to the annual sewage output of 3.2 million people, and 1,240 tonnes of phosphorous, comparable to that from 9.4 million people, according to MacGarvin (2000). The population of Scotland is little more than 5 million people.

To avoid the excessive build-up of sediment wastes in one area, fish farms have practised fallowing or resting of sites for periods thought long enough to allow the natural fauna to recover. However, recent research has cast doubt on the success of this site rotation strategy. Even after months of resting and apparent recovery, a formerly polluted site will deteriorate much more rapidly than a site that has not been previously used (Mackay, 1999).

The use of strong chemicals to treat sea lice can pose environmental risks. Most fall within the scope of the EC Dangerous Substances Directive.

Inland trout farms also cause pollution. Waste products and uneaten food are discharged into nearby waterways where high levels of pollution can be detrimental. For every kilogram of trout produced, pollution is emitted that is equivalent to that produced by 0.2-0.5 persons (Pillay, 1992). The UK produced 13,000 tonnes of farmed trout for the table in 1999. The resulting pollution would have been equivalent to the untreated sewage from more than 2.5 million people.

Anti-Foulants

Sea cage netting can become encrusted with growth that restricts the free flow of water through it, thus affecting the level of oxygen-rich water available to the fish and reducing the removal of wastes. To avoid this, larger nets are coated with an antifoulant chemical. Copper and zinc-based anti-foulants are widely used. Each newly treated net is believed to release around 4-5 kg of copper – listed under the European Union Dangerous Substances Directive - into the environment over the first 3 days after treatment. The level of biological risk from this is poorly understood, but the Scottish Environment Protection Agency (SEPA) warns that a complete ban on these chemicals could result following further research (Mackay, 1999).

Threats to Wild Fish - Genetic Contamination from Fish Farm Escapes

Escapes from fish farms have become a fact of life. During 2000 there were 21 reported escape incidents from salmon farms involving over 411,000 salmon (FRS Marine Lab, 2001). This is nearly double the number of escapes for the previous year. To put these figures into context, farm escapes now outnumber catches of wild salmon by seven to one (Staniford, 2001).

Escapes can result from careless handling, storm or predator damage, or through deliberate releases of economically unviable smolts (young salt-water-ready salmon). And it's not only salmon that escape. Farmed trout are also capable of mass breakouts. In 2000, there were six reported escape incidents from Scottish Rainbow trout farms involving over 63,000 fish (FRS Marine Lab, 2001).

Farmed salmon have been subject to selective breeding programmes since the 1970's to develop production traits desirable to the fish farming industry. These include faster growth rates and later sexual development. Large-scale escapes mean that the ex-farm fish compete with wild stocks for finite food and spawning habitat. There are reports of farmed salmon caught by anglers in Scottish rivers even having salmon eggs and parr (young freshwater salmon) in their stomachs (Orr, 1999).

Fears for the impact on wild populations go beyond wild fish being swamped by sheer numbers of escapees. In 1991, the UK Salmon Advisory Committee expressed its concern that interbreeding between farmed and wild fish may result in the offspring having a reduced ability to cope in the natural environment. This stems from wild fish being genetically adapted to life in their local environment. Simply removing a salmon to a different river can lower the fish's ability to survive. It follows then that widespread genetic pollution from fish farm escapes could have a detrimental effect on the survivability of wild populations. In 1999, SEPA's Professor Mackay declared that genetic pollution should be recognised as a "real and present danger."

There have been a number of sightings of farmed salmon apparently being stranded or caught out by the tide. Commenting on this occurrence in The Orcadian newspaper (28/09/00), marine biologist, James Mortimer said it is "unheard of for wild fish to be ignorant of the phenomenon that is known as tide." This incident serves as a clear illustration of how farmed fish are poorly adapted to life in the wild. Yet their presence in large numbers is likely to displace wild salmon.

Threats to Wild Fish - Transfer of Parasites to Wild Stocks

Sea lice infested farmed salmon have been blamed for the increased death rates amongst wild sea trout. Wild fish swimming past fish farms become infected with sea lice and suffer higher mortalities due to stress induced by the parasites. Sea trout numbers have shrunk to a fraction of what they used to be a decade ago in some rivers on the Scottish west coast. This area, of course, is where salmon farms are most concentrated.

Wild salmon stocks have also been affected. Staniford (2001) documents the decline: "Between 1983 and 1997 farmed salmon production in Scotland increased from 4,000 tonnes to nearly 100,000 tonnes and the wild salmon catch decreased from 1,220 tonnes to 267 tonnes. Wild salmon catches in 1999 were less than 200 tonnes with farmed salmon production 127,000. The decline of wild salmon is particularly marked on the west coast where the vast majority of Scotland's 350 salmon farms are located. The latest figures supplied by the Scottish Executive for catches of wild salmon for 1999 show an overall decline of 39% since 1998 – the lowest since records began in 1952. However, there is a 64% decline on the west coast whilst on the east coast, where there are only a few fish farms, the decline is only 8%."

According to Mackay (1999) of the Scottish Environment Protection Agency (SEPA), the link between farmed salmon and declines in wild fish stocks has been made to the point where it should be "accepted as beyond reasonable doubt." Mackay describes this particular environmental effect as at "near-crisis level".

Research suggests that sea lice would need to be effectively eradicated to protect wild stocks from being affected. SEPA has suggested that the location or expansion of salmon farms near the wild fish migratory routes and feeding grounds could soon be severely curtailed if not banned.

Escaped farmed salmon now outnumber catches of wild salmon by seven to one. 'Genetic pollution' from escapees breeding with wild salmon can have a detrimental effect on the survivability of wild populations. This will be compounded by the infestation of wild fish with sea lice from salmon farms, causing increased death rates amongst wild populations. The link between farmed salmon and declines in wild fish stocks is recognised as being at near-crisis level.

Action must be taken to drastically reduce the impact of fish farming and farm escapes on wild fish populations.

TOWARD A WELFARE-FRIENDLY ALTERNATIVE -

LESS INTENSIVE METHODS OF AQUACULTURE REVIEWED

Conventional methods of fish farming in Europe are intensive. The sheer scale and intensity of this industrial approach causes serious welfare problems. These result from large numbers of fish being confined at high densities giving rise to prevalent injuries to eyes and fins, deformities, outbreaks of disease, widespread and all too often severe parasitic infection, and high levels of mortality. Add to this slaughter methods that are often far from humane, and it can be seen that intensive farming causes great suffering to the fish involved. But are there alternative ways of rearing Britain's annual production of 70 million farmed fish that are more welfare-friendly? A discussion of the welfare merits of two different and emerging approaches to more extensive fish farming follows.

ORGANIC FISH FARMING

Terrestrial organic farming has become synonymous to many with safe, environmentally sound and welfare-friendly food production. The term "organic" is surely one of the hottest brands in the current food industry. Great expectations are then raised at the prospect of organically farmed fish.

In the UK, three organic farming organisations; Food Certification Scotland, the Organic Food Federation, and the Soil Association, have produced a joint set of standards for organic fish farming (FCS et al, 2000). About a dozen organic salmon and trout farms have so far been established. Organic trout went on sale in 1998, with organic salmon becoming available the following year. The organic salmon farms are sited around Orkney and Shetland. Organic fish farm initiatives have also developed in the USA, New Zealand, Norway and Ireland.

Organic salmon and trout are reared in pens or sea cages similar to those used by conventional fish farms. The difference with the organic method is described as the production of fish free from artificial ingredients and colorants, and reared with low stocking densities. Organic standards also place limits on the artificial manipulation of the fishes' environment, a ban on chemical pesticide treatments for parasite control, and insist on minimal contamination of the natural environment. Slaughter methods that are unacceptable on welfare grounds such as carbon dioxide stunning, or asphyxiation in air or on ice are prohibited.

Does Organic Fish Farming Offer Welfare Benefits?

Opinions have been divided over the merits of giving less intensive fish farming the label "organic". Britain's leading organic farming body, the Soil Association, has reservations. It sees the current standards as 'interim' in recognition that organic fish farming is at an early stage and admits that there is still work to be done before it fully complies with organic principles.

Animal welfarists have reacted sceptically to the keeping of organic salmon in sea cages, the issue, which the Soil Association admits, is probably the "most emotive".

It is argued that confinement of salmon in sea cages is little different from keeping cattle or sheep in a field. This analogy is clearly false as 2,500 organic salmon may be kept in a cage measuring 10m x 10m x 10m (Soil Association, 2000). Perhaps the closest analogy is the keeping of turkeys in semi-intensive 'pole-barns'. These are sheds with natural lighting and ventilation in which the turkeys can roam inside, but can never leave its confines. How well this practice for fish fits with the Soil Association's general prohibition on "permanent housing of livestock" for terrestrial animals is questionable.

Looking more widely, the welfare merits of organic fish farming need to be assessed against the most pressing welfare issues; high stocking densities and attendant problems of injuries, cataracts, etc., and slaughter methods for both salmonid species, and sea lice control in marine salmon.

Organic salmon and trout are stocked at considerably lower stocking densities than those widely used in conventional fish farms. This not only means that each fish has more space to carry out its natural behaviours, but also the number of fish for a given cage will, of course, be lower. So taking the example above, the organic salmon cage might contain 2,500 fish, compared with 3,750-5,000 in a conventional Scottish cage, or even 7,500 fish in the Norwegian equivalent. Low stocking rates are an important determinant of a good welfare-friendly system. Organic fish farms should be self-limiting on stocking rates anyway. This is because too many fish confined too tightly together is likely to lead to fish under stress and therefore susceptible to disease. This would run counter to the organic principle of minimising the need for veterinary intervention.

Genetically engineered fish are not permitted under the UK organic standards. Neither are fish that have had their chromosomes manipulated to produce sex-reversed fish that are all the same gender, or induced to be genetically sterile. Forbidding these practices is a definite welfare plus for the organically produced fish.

Infestation of salmon with parasitic sea lice is a serious welfare problem. Failure to treat the infestation properly can lead to fish suffering and dying. UK organic standards permit two methods of dealing with sea lice; the use of parasite-eating wrasse as "cleaner" fish to eat the lice; and bathing the affected fish in hydrogen peroxide. Using wrasse may be welfare-friendly for the salmon but it certainly is not for the wrasse. Many wrasse may die during the first winter in the cage when lice numbers are low, or may be bullied or eaten by larger salmon. Treating infested salmon with hydrogen peroxide is seen as another environmentally friendly alternative to the conventional farmer's range of chemical treatments. Again it is not welfare-friendly. Hydrogen peroxide is a highly aversive irritant to the salmon and can cause mortalities. It also requires the fish to be crowded together before application, which they find stressful. It almost goes without saying that there must be a balance between the salmon's aversion to the treatment, and the illness and death through not treating. The best solution is to avoid parasite infestation altogether.

In practice, the Soil Association reports that none of the certified organic salmon farms are currently using wrasse. Organic farmers aim to avoid sea lice infestations, believing that "if an operation is having to treat regularly, then something is fundamentally wrong." However, a welfare-friendly alternative to wrasse or hydrogen peroxide is urgently needed.

Site selection is an important part of organic management. Many sites on the Scottish west coast, where sea lice appear to be endemic, would not be suitable for organic salmon rearing. A clean site with fast-flowing water is required. Fish farms around Orkney are regarded as not having a problem with sea lice due to the strong currents in the area. This selective site requirement should be applauded for its common-sense approach to better welfare. However, organic salmon production could be limited by the availability of suitable sites.

Fish slaughter is an area of major welfare concern. UK Organic standards demand that fish are killed by a method that renders them instantly insensible immediately they are taken from the water. Prohibited methods include suffocation in air or on ice, allowing conscious fish to bleed to death, and stunning using carbon dioxide, all methods that cause suffering. Harvesting of organic fish must be done either by rendering them unconscious by a blow to the head followed by gill cutting, or by electrocution. So long as these methods are carried out effectively, the welfare of the fish should be protected.

Organic fish, in common with their conventional counterparts, are starved for 7-10 days before slaughter. This is to clear food remains from the gut before slaughter. Although temperature dependent, it takes 24-48 hours for gut clearance. There is no demonstrable difference in product quality from a fish starved for 7-10 days, and one starved for no more than 72 hours. However, prolonged starvation of fish accustomed to regular and plentiful feed is highly likely to be detrimental to their welfare. It is therefore not acceptable for fish to be starved for prolonged periods purely for commercial reasons.

Organic fish farming is at an early stage of development. It represents a more extensive alternative to the intensive industry that currently dominates Europe's aquaculture scene. It therefore sets a more sympathetic environment for higher welfare. Current organic standards need tightening to better protect welfare.

On the supermarket fish-counter, the most likely difference to be noticed between factory farmed and organic fish is the organic version's slightly paler flesh colour. This comes from a prohibition on synthetic colorants such as canthaxanthin and anthaxanthin, both widely used in conventional production. To avoid any mix-ups, organic fish have to be tagged and labelled before they reach the retailer. Where unpackaged fish are offered, both ends of the fish must be tagged. Packaging labels or tags must bear the terms "farmed" and "organic", and will also carry the symbol of the relevant organic organisation. Several supermarket chains offer organic farmed salmon and trout, including Safeway, Sainsbury's, Tesco and Waitrose, whilst ASDA and Co-op sell organic trout only.

Organic fish farming offers consumers a semi-intensive alternative to industrially reared salmon and trout. Rearing fish at lower stocking densities and with strict slaughter standards means that organic standards have some strong welfare-friendly credentials. However, allowing the treatment of sea lice in salmon using cleaner fish (wrasse) and hydrogen peroxide baths, along with

prolonged periods of starvation for the fish before slaughter are welfare oversights that should be addressed urgently.

SEA RANCHING: A FREE RANGE ALTERNATIVE TO CAGES?

Free range farming of salmon and other species is already being practiced in many countries and is attracting increasing interest worldwide. The sea ranching of salmon involves rearing young fish and releasing them at the point when they would naturally migrate to sea. The fish then grow out at sea where they feed on a natural, totally unrestricted, free range basis. When they mature, the fish return to their release river where they can be captured.

The rate at which released salmon are recaptured has been reported as 15% in Iceland, 12-40% in Sweden, and 6% in Scotland and Ireland (Sedgwick, 1988). These figures compare with 10% of wild fish returning to their home river after maturing at sea.

> "Ranching salmon, which is a means of taking advantage of the natural growth of the fish in the open sea, is an attractive proposition, and one of the most exciting possibilities open to salmon farmers."
>
> Stephen Drummond Sedgwick, 1988

Sea Ranching Around the World

Twenty-seven countries have already been involved with ranching to some degree (Bartley, 1999). To get an idea of the scale of sea ranching around the world, we only have to look at Japan and Alaska. Japan is the world leader in sea ranching. 2 billion Chum salmon are released annually in Japan with a returning adult recapture rate of 2-4%. About 100 million Pink salmon, and 20 Million Masu salmon were also released in 1994, along with about 800,000 of the non-native Sockeye salmon (Kitada, 1999).

In Alaska, salmon harvesting is an important industry and accounted for half of the world's entire salmon harvest in 1980. In 1995, more than 33 million hatchery-reared salmon were recaptured as adults. The fact that both ranched and wild salmon fisheries were able to continue successfully side-by-side bodes well for sea ranching as the 'free range' alternative to fish farming with cages.

The cage farming of salmon has been banned in Alaska since 1990 due to fears over the damaging affects of fish farming on wild salmon (Knapp, 1999).

There are potential benefits to the welfare of fish from ranching as opposed to rearing in a cage or pen. For example, the obvious behavioural freedom and natural environment reducing the disease problems associated with intensive aquaculture. However, sea ranching should not be permitted where it is likely to have a detrimental impact on the aquatic environment, on existing fisheries, or on the fish themselves.

Sea ranching offers an extensive alternative to intensive fish farming. It involves the release of juvenile salmon to grow in their natural environment, before being

recaptured when mature. This system has the potential for high welfare. However, it brings with it natural threats such as increased predation and food shortage. The potential for sea ranching to damage wild stocks through genetic pollution should be addressed before embarking on any such venture.

CONSUMERS - IT'S YOUR CHOICE

Intensive fish farming has made salmon and trout cheap and plentiful, but at a high price for animal welfare and the environment. More recently, concerns over chemical contaminants in farmed salmon have raised consumer health fears.

Of Chemicals & Cages

A BBC documentary in January 2001 suggested that a single portion of salmon from a Scottish fish farm can contain more than the safe level of toxic chemicals recommended by the World Health Organisation (WHO). Miriam Jacobs of surrey University claimed that levels of man-made polychlorinated biphenyls (PCBs) in a 100 gram serving were equivalent to the WHO limit on daily exposure for an adult. The contamination was believed to come from fish feed, containing a large proportion of wild-caught fish (The Times, 04/01/01). A recent study by Jacobs (2000) concludes that the "possible contribution to dietary intakes of organochlorines from farmed Salmon could be significant for high consumers".

Residues of the chemical pesticide, Ivermectin were recently found in four samples of salmon (VMD, 2000). Ivermectin is not authorised for use in fish and the samples have been subject to investigation by the Ministry of Agriculture's legal branch and the Scottish Environment Protection Agency (SEPA).

Samples of farmed trout have recently been found to contain residues of leucomalachite green, a substance that has never been authorised for veterinary medicine and has not been proven safe for use in fish farming (VMD, 2000).

More Fat

Farmed salmon and trout contain more fat than their wild-caught cousins. Figures from the US Department of Agriculture comparing farmed fish with their wild equivalent show that farmed Atlantic salmon is 50-70% higher in total fat content, whilst farmed Rainbow trout has about 20-55% more fat (USDA Nutrient Database, 1999). Farmed salmon can also contain 15% less protein and 2-3 times less of the healthy Omega-3 oils than wild salmon (Staniford, 2001).

Choices

Previous advice to consumers worried about the welfare, environmental and health aspects of farmed fish was to buy only wild fish. However, wild salmon populations have since declined, making the wild version hard to come by in the UK. Parasite infestation from farmed fish, pressure from fish farm escapes, and problems with the salmon's freshwater habitat have all been blamed. As a result, fresh wild salmon from the UK is more expensive than farmed fish. Tinned wild Pacific salmon from the west coasts of Canada and the USA is more readily available (BBC, 2001).

Alternatively, several supermarkets are now stocking fresh organic salmon and trout. These are produced less intensively, and free from artificial chemicals and colorants. Low stocking densities, strict slaughter standards, and limits on the artificial manipulation of the fishes' environment add up to a system with strong welfare credentials. Genetic engineering and chromosome manipulation techniques such as sex-reversed and triploid fish are not allowed under the standards. To make sure that a fish is organic, the labels on the packaging or tags must read “farmed” and “organic”, and will carry the symbol of the relevant organic organisation.

New Labelling Law

New legislation agreed in Brussels has come to the aid of concerned consumers. From 1st January 2002, fish must be labelled according the production method (taken at sea or farmed) (EC 104/2000). This compulsory labelling requirement will help those consumers wishing to avoid intensively farmed fish.

OTHER FARMED FISH SPECIES

Consumers may find an increasing number of other farmed fish species on sale. What follows is a summary of farming methods and welfare problems evident in each case.

Cod (Gadus morhua)

Cod farming is seen as a potentially important farm species. This is causing a wave of interest, not least because of the decline of the traditional cod fishery. Rearing trials have been conducted in Canada, Denmark, Norway and the UK. A total of 148 tonnes of farmed cod were produced in Norway in 1998. Over 15 tonnes were produced from Scottish farms in 2000, with 41 tonnes predicted for 2001 (FRS Marine Lab, 2001).

Although early days, it is being suggested that cod could be reared more intensively at higher stocking rates than already tightly stocked salmon. The two-stage rearing process involves the production of cod fry in tanks, then rearing for slaughter in tanks or sea cages as for salmon. Cod can be quite aggressive and early advice is to grade them frequently to sort them into groups according to size. This will cause a welfare paradox as cod become stressed if handled too often.

Another sign of cod farming's early intensification is the suggested use of controlled lighting to manipulate the breeding cycle of broodstock so they produce eggs all year round. The use of strong additional lighting is also seen as a way of preventing growing cod from maturing early, and thereby increasing their weight at slaughter from 3.5 kg to an estimated 5.5 kg (Kvenseth and Hempel, 2000).

Slaughter methods for cod are likely to be similar to those used for salmon.

Interest in cod farming is not new. The successful rearing of cod juveniles in the mid-1980's created an "avalanche of interest" in farming this species. Interest dwindled due to a number of economic and practical problems. These included the cod maturing too early, and also having an enlarged liver causing the body to be deformed. Cannibalism has been a problem in the intensive rearing of cod juveniles, causing the loss of most of the juvenile cod involved in Norway's research programme in the early 1990's (Oiestad, 2000).

One difficulty being tackled is the rearing of cod fry that, unlike salmon, need to be fed on live food (zooplankton and brown-shrimp) to survive. There is a feeling that this requirement could be a limiting factor in cod farming's expansion. However, the elements needed for launching a profitable industry are now said to be in place. The otherwise similar methods of rearing as for salmon have led to cod being seen as a potential option for salmon farmers looking to diversify.

Eel (Anguilla anguilla)

Eels can be reared intensively in land-based fish farms. Re-circulation systems are used, which entail the same water being circulated, cleaned and re-circulated (in a closed system), rather than relying on water flowing through the system and then on down the river as in raceways or earth ponds. Not surprisingly, 'environmentally tolerant' species, including eels, are farmed this way. Eels can be stocked at high densities and are fast-growing fish, reaching slaughter weight in 10-15 months. They are killed when weighing 125-250 grams (Ley, 1998). Eel farming relies on taking elvers (young eels) from the wild and rearing them in captivity. European eel farming is centred in Denmark, Italy, and the Netherlands.

Commercial slaughter methods for eels are intolerably inhumane. They are either killed by cutting the necks of the fully conscious fish, or anaesthetised and allowed to bleed to death. Alternatively, they may be killed by the traditional method of bathing them in dry salt, which gradually penetrates and desiccates their bodies. The fish are then gutted despite an estimated 80% of them being still alive. Although the death rate amongst the eels increases after gutting, "a significant proportion are still alive after 30 minutes" (van de Vis, 1997). Eels, which are known to leave the water and cross damp land during their migrations, cannot be killed by simple exposure to air, as it "takes too long". Killing by neck-cutting of conscious fish or bathing them in salt are totally unacceptable on welfare grounds.

Dr van de Vis compared these methods with an experimental killing method whereby a hole was made in the eels' head using a punch. This caused an instant loss of brain activity or very low levels, resulting in "markedly decreased stress" in the fish.

Halibut (Hippoglossus hippoglossus)

The Atlantic halibut is one of the largest species of flatfish and can grow to a weight of 250 kg or more in the wild. It has been identified as another species that could offer important prospects to salmon farmers for diversification. Development work is being conducted in Norway, Iceland and Scotland. Work has focused on overcoming difficulties in the mass production of fry for farming. The young fish need live food and problems still exist in reliably rearing them beyond this stage.

Young fish are reared in tanks until they weigh more than 100 grams. Frequent grading is needed to reduce aggression. The protruding eyes on these flatfish are particularly susceptible to damage or attack from rearing companions. Growing the fish for slaughter takes place in tanks or sea cages similar to those used for salmon. Cages should have a flat well-tensioned floor, as the fish spend a lot of time swimming close to or lying on the bottom. Shelves can be incorporated within the cages to increase the stocking rate. It is thought that stocking densities similar to those used for salmon may be feasible for this species (Martinez Cordero et al., 1994).

Halibut is a gregarious fish. In the rearing environment, they group together in layers that can be several fish deep. Aggression appears to be inhibited at high densities (Council of Europe, 2000). However, this does not necessarily mean that they do not find such high stocking densities a welfare problem. It is known that in both laying hens (Al-Rawi & Craig, 1974; Baxter, 1994) and territorial fish such as Rainbow trout (Pickering, 1992), aggression can be diminished at both low and very high stocking densities. The greatest levels of aggression can be experienced at intermediate densities. Welfare is likely to be best at the lower densities, but poorest at the highest. This suggests that the relationship between social interaction and population density is not linear, but dome-shaped, at least for these species. This relationship should therefore not be taken as an indicator of good or bad welfare without proper assessment of other factors.

It currently takes three years to rear a 2-3 kg halibut for slaughter. Slaughter methods include stunning using carbon dioxide or percussion. The latter method is difficult to do without damaging or destroying the eyes (Wall, 1999). Alternatively, severing the spinal column may be used to kill them. However as Wall (1999) points out, this "may not cause immediate insensibility" in the fish and is likely to cause suffering.

Despite expectations of more than 50 tonnes of halibut from Scottish farms in 2000, only 4.5 tonnes were produced (FRS Marine Lab, 2001). Production is expected to reach 10,000 tonnes by 2011, and would require 30 cage sites and 10 hatcheries (Holmyard, 1998).

Sea Bass (Dicentrarchus labrax) and Sea Bream (Sparus aurata)

Both these whitefish species are widely farmed intensively in the Mediterranean region in countries such as Cyprus, France, Greece, Italy, Spain and Portugal.

Turbot (Psetta maxima)

Turbot is another flatfish species for which farming techniques are being developed. As with other marine species, fry need to be given live food to survive. Turbot is a sedentary fish that frequents the bottom of the tank or cage. It apparently grows at high stocking densities, whereby the fish can be overlapping or even layered on top of each other. Rearing and slaughter considerations are likely to be similar to Halibut (see above). Turbot is farmed in France where 900 tons were produced in 1999, and on a small scale in Ireland and Scotland. One Scottish company is now successfully rearing turbot in the same tank as cod. Farmed turbot is on sale in several UK supermarkets including Tesco, Sainsbury and Waitrose (Holmyard, 2000).

SUMMARY OF RECOMMENDATIONS

1. **Maximum stocking densities of 10 kg/m^3 for salmon smolts at sea, and 20 kg/m^3 for trout reared in freshwater should be introduced urgently through legislation. Further reductions should be considered in the light of future practical and scientific evidence, taking full account of welfare indicators such as abnormal behaviour, injuries, disease, parasitic attack, and mortality.**

2. **Salmon sea lice infestation should be controlled by reduced stocking densities and less intensive management. Careful site selection should ensure clean, fast-flowing water to reduce the likelihood of serious parasitic attack.**

3. **The use of hydrogen peroxide and wrasse as "cleaner fish" for treating sea lice are both unacceptable on welfare grounds.**

4. **Comparative work is needed to assess the welfare aspects of different grading methods using non-invasive techniques. This work should compare the levels of stress caused by the different grading systems, looking at how much physical damage they cause to the fish (e.g. scale loss and abrasions), the length of time fish go off their feed, and the post-grading 'growth check' – the drop in growth rate in the days immediately after grading. The stress caused to the fish by grading should be minimised.**

5. **To protect fish welfare, transport times should be reduced to the absolute minimum. Water conditions for the fish in transit, such as oxygen levels, carbon dioxide, and pH, should be monitored at frequent intervals.**

6. **Biotechnology techniques involving chromosome manipulation (e.g. sex reversal and triploidy) should be prohibited.**

7. **The use of genetically engineered fish for farming should be prohibited.**

8. **The usual practice of starving farmed fish for several days, even weeks, before slaughter is highly likely to be detrimental to fish welfare. Starvation periods of longer than 72 hours should be prohibited.**

9. **Widely used slaughter methods for farmed fish such as suffocating fish in air or on ice, bleeding to death without pre-stunning, and the use of carbon dioxide for stunning are inhumane, totally unacceptable, and should be prohibited urgently.**

10. **Only slaughter methods that cause an instant death or render fish instantly insensible to pain until dead should be permitted. These include percussive stunning techniques and electrocution where properly designed and effectively carried out. In the case of electrocution, the**

electric current must be sufficient to stun and kill the fish otherwise considerable suffering could result.

11. **Supermarkets selling farmed fish should raise their welfare standards by demanding that suppliers rear fish at much reduced stocking densities, use only humane slaughter methods, and stop the practice of prolonged pre-slaughter starvation.**

12. **Wildlife should not be shot, drowned or otherwise harmed as an anti-predator measure. Every precaution should be taken to avoid predators gaining access to the stock through the use of anti-predator nets and other non-lethal deterrents.**

13. **In view of the fact that the farming of salmon, trout, halibut and cod adds pressure to wild fish stocks and is therefore environmentally damaging, the sustainability of intensive fish farming should be reviewed.**

14. **Action must be taken to drastically reduce the impact of farmed fish and farm escapes on wild fish populations.**

15. **Organic fish farming offers consumers a semi-intensive alternative to industrially reared salmon and trout. However, allowing the treatment of sea lice in salmon using parasite-eating wrasse as "cleaner" fish and bathing in hydrogen peroxide, along with prolonged starvation of fish before slaughter, are welfare oversights within organic standards and should be addressed urgently.**

16. **Sea ranching offers an extensive alternative to intensive fish farming. It involves the release of juvenile salmon into their natural environment where they grow and have the potential for high welfare. The potential for sea ranching to damage wild stocks through interbreeding – genetic pollution - should be addressed before going ahead with any such venture.**

Conclusion

Farmed fish now represent the UK's second largest livestock sector after broiler chickens. The vast majority of the 70 million farmed fish produced in the UK are reared intensively, whereby large numbers of fish are confined in a small area. Intensive rearing methods, together with often appallingly cruel and widely used slaughter practices such as suffocation on air or on ice, and carbon dioxide stunning, are unacceptable on welfare grounds. Urgent action is needed to stop the widespread suffering of intensively farmed fish.

APPENDIX I

Consultation and Acknowledgements

A wide range of people offered their views during the preparation of this report, either by direct discussion or by responding to requests for information via questionnaire. The author offers grateful thanks to all those who took the time to discuss the welfare of farmed fish.

Consulted via Interview

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Hugh Horrex, Middleton Engineering

Hydro Seafood GSP

Steve Kestin, University of Bristol

Marine Harvest (Scotland)

Dr Pike, IFOMA

Dave Robb, University of Bristol

John Robins, Animal Concern

Don Staniford, Environmental Consultant

Dr John Webster, Technical Advisor, Scottish Quality Salmon

Consulted via Questionnaire

British Trout Association

Farm Animal Welfare Council

IFOMA

Ministry of Agriculture, Fisheries & Food, Animal Welfare Division

APPENDIX II

GLOSSARY

Alevin	newly hatched fry of the salmon family that are feeding from the yolk-sac
Brood stock	fish set aside for breeding purposes
Fallowing	a rest period for cages or ponds without fish
Fingerling	fish of about finger length or 10 cm long
Fry	young fish, between alevin and fingerling stages that are eating external food
Grilse	a salmon that becomes sexually mature after one summer at sea
Milking	the stripping of milt from male fish
Milt	the semen of male fish
Parr	fingerling salmon distinguished by a series of darker patches, or parr marks, on the flanks
Photoperiod	the period of light during 24-hours
Priest	a hand-held club used to stun fish percussively at slaughter
Raceway	a long tank, usually of concrete, through which water flows at a steady rate
Smolt	the juvenile salmon after parr stage, silver in appearance that is able to enter seawater.
Stunning	a process which causes loss of consciousness in an animal
Triploid	an animal with three sets of chromosomes (containing genetic material - DNA) instead of the usual two

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