Report on the welfare of farmed fish

The fish

1. The species covered in this Farm Animal Welfare Council (FAWC) report are salmon (*Salmo salar*) and trout (*Oncorhynchus mykiss* and *Salmo trutta)* with brief comments on carp *(Cyprinus carpio*). The welfare of those species of wrasse which are used for parasite control during salmon farming (*Ctenolabrus rupestris, Centrolabrus exoletus* and *Crenilabrus melops*) is also discussed. Information about FAWC and a list of those who gave evidence may be found at Appendices A and B. There is a glossary at Appendix C.

The biology of the fish

2. In some respects, fish are very different from birds and mammals because of their adaptations for aquatic life. For example, they obtain the oxygen which they need from water via their gills. The heart and circulatory system are adapted to this means of respiration. The systems of many fish for eliminating waste from the body depend on the presence of much water for dilution and dispersion. On the other hand, in some aspects of their biology, fish are very similar to birds and mammals. The basic functioning of the muscles, liver, hormonal control mechanisms and nervous system is similar in fish and in other vertebrate animals including those which are warm-blooded. Of particular significance in relation to the welfare of animals is that both the adrenal system producing hormones in emergency situations and those senses which are not specific for use in the aquatic environment, function in very similar ways in fish and in mammals.

3. Almost all fish live the whole of their lives in water and show a maximal emergency response when removed from water, even for a very short period. This response includes changes in heart rate, increased production of adrenaline, noradrenaline and cortisol and vigorous muscle contractions which could result in escape and return to water. Some parts of the short-term emergency responses are shown in other disturbing circumstances. In water, low oxygen tension and the presence of toxic substances can also lead to emergency responses, as can attack by predators or other members of their own species. Vigorous avoidance and the associated physiological changes, whether shown in response to a sudden disturbance or to stimuli which the fish have learned are dangerous, often indicate fear in the fish.

4. Physical and social problems which are long-lasting may also result in adrenal and other physiological responses. However, as in mammals, the levels of adrenal hormones do not remain high for long periods. Prolonged problems and frequent activation of adrenal responses can result in immunosuppression, with increased susceptibility to disease, and inhibition of reproduction. There may also be effects, via changes in growth hormone levels, on fish growth. All of the scientific evidence concerning such effects makes it clear that the term stress is certainly relevant to fish and that the means by which stress effects are mediated are very similar to those in mammals (Strange and Schreck 1978, Pickering 1981, 1989a,b, Sumpter *et al* 1986, Flos *et al* 1988).

5. Evidence that the term pain is applicable to fish comes from anatomical, physiological and behavioural studies whose results are very similar to those of studies on birds and mammals. The fact that fish are cold-blooded does not prevent them from having a pain system and, indeed, such a system is valuable in preserving life and maximising the biological fitness of individuals. The receptor cells, neuronal pathways and specialised transmitter substances in the pain system are very similar in

fish to those in mammals (Mathews and Wickelgren 1978). Localised tissue damage such as cuts and bruises and electric shocks to the skin result in electrophysiological changes in the nerves connected to pain receptors in fish. Behavioural avoidance responses are often shown in circumstances which might be expected to involve pain. Fish can learn to avoid places where they had unpleasant experiences including those in which they received tissue damage likely to involve pain (Ingle 1968, Verheijen and Buwalda 1988). The anatomy of the fish brain is different in some respects from that of the mammalian brain but there are some functional similarities (Echteler and Saidel 1981, Laming 1981, Ehrensing *et al* 1982, Busch 1992). It is not possible for scientists to determine exactly what any other individual is experiencing and we do not know what fish feel but the evidence available makes it very likely that at least some aspects of pain are felt by fish. In addition to any effect of pain, injury to a fish results in poor welfare where there is impairment of function or increased susceptibility to disease.

6. The needs of fish can be determined by studies of stress and welfare in these animals. Some of such work has involved examining the conditions in which fish will grow and reproduce. Other work has concerned the factors which affect the incidence of fish diseases. A relatively small amount of work has been carried out on other indicators of poor welfare and on studies of preferences in fish. Farmed fish need unpolluted water of an appropriate temperature and oxygen level, an adequate quantity and quality of food, a stocking density which allows for normal movement and social interaction, and good possibilities to avoid perceived danger. The means of meeting the various requirements interact with one another, for example a sufficient rate of water flow past the fish will provide oxygen, remove waste products and mitigate some of the effects of crowding. Fish also have specific needs in relation to handling and management procedures.

7. The Atlantic salmon *Salmo salar* is a species only relatively recently used in fish farming but the output of salmon farms has soared over the past twenty years from almost nothing to many thousands of tonnes per year. In the wild the species is widely distributed on both sides of the north Atlantic in the cold to temperate zones. It is successfully farmed mainly in Northern European waters. The most significant feature of the salmon is its anadromous life-cycle; the early years are spent in freshwater but, after a physiological transformation, the young fish migrate to sea, completing growth there over one or more years and attaining sexual maturity, or near maturity, before returning to their river of birth to spawn. Other important features of the salmon are its preference for cool water with high oxygen content and its carnivorous habits.

8. The rainbow trout *Oncorhynchus mykiss* is a native of the Pacific drainages of North America but it has been transported all over the world and is now acclimatised very widely. In the UK it has not been able to adapt fully to natural conditions except in one or two special circumstances. It has been the easiest of salmonid fish to farm and is the basis of trout farming the world over. Like the salmon it is carnivorous and needs fresh, running water to spawn but it can grow in much more varied circumstances than salmon and in fresh, brackish or even sea water. In the wild this species and the brown trout have river, lake and sea going forms. Rainbow trout are farmed throughout most of Europe.

9. The brown trout *Salmo trutta* is widely distributed in Europe and temperate parts of Asia and Africa and like the rainbow trout it has been acclimatised in many parts of the world outside its normal range. It is like the rainbow trout in its basic life style but under farm conditions it is less easy to rear and grows at about half the rate that is possible in rainbow trout. Its principal commercial use is for re-stocking for angling but some fish are farmed in fresh water or sea water for food.

10. The carp *Cyprinus carpio* is the species of fish reported farmed in antiquity. It is naturally distributed in much of Europe and Asia and has been extensively introduced outside this range. The carp flourishes in warm conditions but grows little, if at all, below 8C. Its natural habitats are lakes and slow moving rivers. It is omnivorous but needs animal protein in its diet. Its oxygen requirements are much less stringent than are those for salmonid fish and it can take air into its buccal cavity for respiration.

STRUCTURE OF THE INDUSTRY

SALMON

11. The farming of Atlantic salmon is based on a method of marine culture first developed in Norway. In Scotland, salmon culture is dominated by multinational corporations and production levels there rose from near zero in the early 1970s to 64,000 tonnes in 1994. In that year there were 119 salmon-producing companies in Scotland operating on 262 sites and employing over 1,200 staff; the ova and smolt industry comprised 68 companies, employing almost 400 staff on 147 sites and produced over 23 million smolts in 1994. In Europe, and indeed, the world, the largest producer is Norway with an output in 1994 of 209,000 tonnes. Other production areas in Europe are the west coast of Ireland, the Faroe Islands and, to a small extent, France and Spain. As production levels have increased so the service industries have become equipped to provide more sophisticated fish feeds, farm equipment, disease treatments, transport, processing facilities and quality-control procedures.

12. There are two distinct phases to salmon farming. First, the freshwater phase which embraces the spawning cycle of egg production and hatching and the feeding of fry until the fish turn into smolts. Large fish farming companies may produce their own smolts but many will be supplied by specialist smolt producers. In the second phase, these smolts, now physiologically adapted to a life in sea water, develop further in the sea. Growth is rapid in this phase and a proportion complete growth to a point where reproduction is possible in one year. These fish are known as grilse. Fish that grow through two or more winters are called salmon. Grilse are usually separated from the rest of the population for slaughter. This is done by grading after 12-18 months at sea and most of the remaining salmon are kept for up to a further year. Selected adult fish will be retained as broodstock.

13. Severe weather places strong constraints on what can be done at sea. Sites are usually chosen to minimise exposure to rough weather conditions whilst providing an adequate flux of clean water. Other natural hazards (e.g. predators) have to be considered and the farms themselves should not have an adverse impact on the environment (see paragraph 16).

TROUT

14. Trout have been farmed for over 100 years in fresh water and in sea water. The trout farming industry is geographically more widely based than the salmon industry and includes a range of farm sizes from a few tonnes per year up to almost 1,000 tonnes per year. Total UK production is fairly stable at about 15,000 tonnes per year. In 1994 production was 16,056 tonnes from 373 registered trout farms. Of this 11,917 tonnes were produced for the table with the balance going for restocking. Production in other European countries is considerably higher, e.g. Denmark with 41,000 tonnes, France with 50,000 tonnes and Italy with 42,000 tonnes. There are two phases in trout farming: hatchery plus fry rearing, usually using bore-hole or spring water; and later rearing which normally utilises river or lake water. Rainbow trout reach a marketable size of about 400g in one year in the south of the UK but not until their second year of life in more northerly regions. Outlets range from casual farm gate sales to organised supermarket distribution.

CARP

15. The farming of carp is near to its northern limit of economic feasibility in the UK and the industry is small, less integrated than salmon and trout farming, and caters as much for sport and ornamental pond use as for food production. In the UK in 1993 there were 175 registered farms which reared carp and total production for food and angling use was 76 tonnes. Carp are farmed extensively in Central Europe and, in terms of total European production, UK output is low.

SITES, EQUIPMENT AND ENVIRONMENTAL CONTROL

SALMON

16. Whilst hatcheries and smolt production units are based on-shore, for their main growth period farmed salmon are in sea cages, although small numbers are farmed in fresh water. Sites at sea need to be carefully selected, for example to avoid excessive exposure to rough sea conditions which could cause cage damage and put staff at risk, but the location must still provide an adequate flux of clean, uncontaminated water. Most sea cages are in sheltered inlets, such as fjords, along the Atlantic coast. Some sites are being established offshore in more exposed positions. The design of cages and equipment should take into account the potential effects of exposure to adverse weather conditions. Increased cage depth can to some extent compensate for the impact of severe weather but there should be contingency plans for the care of the fish under these conditions. Precautions may also be needed against natural hazards, such as predatory mammals and birds, stinging jellyfish, and potentially toxic or oxygen-depleting plankton blooms, as well as man-made hazards such as oil spills and shipping. It is also important to ensure that the farms themselves do not have adverse effects upon the environment or other users of the coastal seas.

Hatchery

17. Salmon hatcheries usually use water from clean burns or rivers. Where necessary this may be filtered or treated with ultra violet light to ensure that it is of suitable quality for the fish. The water is continually flowing to provide oxygen and to clear waste. Farms sometimes require back-up systems, with alarms, to ensure a constant supply of water.

18. The initial production stages of fertilisation, hatching and fry production are mainly conducted indoors. Eggs are placed in incubators which range from troughs and trays that hold a monolayer of eggs to stacks of trays that use space more efficiently and to specially designed containers supplied with upwelling water that can hold tens of thousands of eggs. The newly hatched alevins drop to the bottom of the trough or tray, often onto an artificial substratum, to absorb the yolk sac. After this stage they start to take food and are termed fry.

19. Fry develop in tanks indoors until, on reaching the parr stage, the fish are transferred to larger tanks, usually outside, or to cages in fresh water. Outdoor tanks are netted or covered to prevent predation and keep out debris. Indoor tanks may also have net covers or lids to prevent escape. Some parr are kept indoors in tanks which may be heated and subjected to lighting regimes simulating accelerated seasons so as to become smolts after six months of development.

20. A high level of hygiene is necessary in the hatchery. Before eggs are brought in, all equipment is washed with detergents and left to soak in solutions of iodophore-based or hypochlorite disinfectants before being thoroughly rinsed. The interior surfaces of the hatchery and all furnishings should at least be washed down and preferably sprayed with disinfectants. High pressure hosing and, better still, steam hosing are effective methods of cleaning. All water supply lines and drains should be thoroughly flushed and, where necessary, disinfected. Ideally, the eggs should be disinfected before they are transferred to the hatchery and, once there, frequently inspected to enable the prompt removal of dead or unfertilised eggs. Equipment used to remove dead or inert material from hatching tanks should be disinfected after each session and whenever possible should be dedicated to one tank only. Tanks for growing fry should be cleaned similarly to those for hatching. A bigger volume of water and larger surface area necessitates the use of hand nets to remove dead fish. Water circulation in the tanks should carry inert material to the outfall and the screens over the outfall should be cleaned daily.

Further growth

21. Almost all final salmon production takes place in cages in sea water. There are many designs the two most popular of which are polyethylene circles and galvanised steel square frames supported by flotation collars and from which cages made of synthetic fibre netting are suspended. Circular cages

are more suitable for exposed locations but are usually reliant on boats to service them, while the steel framed cages tend to be parts of a small floating island with steel walkways, some also having storerooms and offices. A tensioned cage observed at one site had a framework of wires under tension and girders around it so that it was kept taut. The mesh was made of heavy gauge material. The intention was to exclude predators such as seals (see paragraphs 222-229). Cage sizes generally were in the region of 15m x 15m x 10m deep, although depth was variable and dependent on the depth of the water under the cages. The requirements of salmon for environmental stimulation are not fully understood and the relationships between these requirements and the welfare of fish could usefully be investigated.

22. Injuries to the snout and fins of salmon are relatively common and readily noticed in cages. Nets have been developed to minimise abrasion and a small mesh size helps to limit skin or fin injuries but at the cost of reduced water flow. Fouling organisms can build up on nets and present an abrasive surface so it is important to keep the nets clean. It is also possible for injuries to arise from collision or aggression between fish. Lesions are potential sites for infection.

23. Cages and sites are often left fallow for disease control and environmental reasons (see paragraph 179). The length of the fallow period may depend on a number of factors including geography, local management agreements and economics. Maintenance of cages is normally carried out during a period of fallowing when nets should be removed, washed and disinfected; cage nets should be lifted, air-dried and then shaken free of debris and the framework of the cage should be cleaned. Nets may be cleaned *in situ* using remotely operated vehicles (ROVs), water jets or divers. An alternative is to change the net when fish are graded.

24. Dead fish are removed from cages by a variety of methods. Some farms we visited used contract divers on a weekly basis, which we do not consider to be adequate, and a few used ROVs, controlled remotely from the surface, on a daily basis. Another popular method is a 'dead sock'. This is an elongated tube of netting attached to the base of the mesh cage into which dead and dying fish fall. The sock may be closed and raised to the surface for dead fish to be removed. There is also a method for the removal of dead fish which uses an air lift. Such methods are good because dead fish can be removed daily. Whichever method is used, care should be taken to minimise disturbance to the remaining fish (see paragraph 55). FAWC was told that in very large cages the dead sock method is difficult to use effectively. Large cages should not be used unless an effective and satisfactory method for daily removal of dead and moribund fish is available.

25. Salmon in sea cages are fed either by hand or, more commonly in recent years, by automatic feeding equipment which scatters feed over the surface of the water. There are some feeders which pump feed suspended in water into the cage. Automatic equipment must be checked frequently and properly maintained.

Recommendations: salmon

26. An adequate water supply of suitable quality for the fish must be available in salmon hatcheries and in tanks for older fish.

27. Systems for providing an adequate supply of good quality water in hatcheries and for growing fish in tanks, must have alarms to indicate malfunction, must be inspected regularly and should be monitored carefully.

28. Hatcheries, equipment and tanks for salmon should be properly cleaned between batches.

29. Sites for sea cages and the design of the cage must be chosen so as to avoid unacceptable conditions for the fish in good or bad weather.

30. Outdoor tanks and sea cages should have adequate means for protection of the fish from predators.

31. The requirements of salmon for environmental stimulation should be investigated.

32. Netting used in the construction of sea cages should present a smooth surface to limit injuries to the fish. Studies should be carried out to find out how to minimise injuries to the snout and fins of salmon in cages.

33. An adequate method for the daily removal of dead and moribund fish from tanks and sea cages must be available (see also paragraph 64).

34. Automatic feeding systems must be properly maintained and should be inspected every day where weather permits.

TROUT

35. Trout farm sites require a source of clean flowing water because the fish are usually held at high stocking densities. The traditional farm consists of a set of purpose built narrow ponds, 1m or less in depth, lying parallel to one another with a common inlet channel for water and a common outflow channel which is often also used for fish production. Water requirements are in tens of millions of litres per day and it is important that there is adequate water flow. Sophisticated farms employ concrete tanks, called raceways, for which the water intake and outflow discharges are of pipework. Some farms use circular tanks in which spiral water movement towards the central drain helps carry away detritus. Some farmed trout are kept in cages, similar to those used for salmon, in fresh or salt water locations. FAWC believes that with all designs, the aim should be good fish welfare rather than just fish survival and growth.

Hatchery

36. Hatcheries are usually indoors because eggs and fry require a great deal of attention and much of the work is done in the winter months. Whilst the water supply for a farm producing fish for sale usually comes from surface sources such as rivers or lakes, for the hatchery pure water is needed. A bore hole, a spring supply or sterilised river water is advisable. Without these relatively pure water sources, the high densities employed for eggs and small fry would be impossible because of the high risk of parasite infestations or disease. Water is continually flowing through the tanks to provide oxygen and to clear waste. Hatcheries should have a back up system with alarms to ensure a constant supply of water. A further benefit of ground water is its uniformity of temperature in the UK at approximately 10C throughout the year.

37. Within the hatchery the eggs are incubated in monolayers in trays or packed into funnels of about 10 litres capacity with upflowing water. On emergence, and after completing yolk sac absorption, the fry are held indoors in shallow trays or circular tanks where they stay until they reach a weight of about 5g. Feeding is by hand or by automatic feeder which introduces a small amount of food into the water at regular intervals or continuously.

38. Hygiene is as important in trout hatcheries as it is in those rearing salmon (see paragraph 20). The same types of precautions should be taken prior to new batches of eggs and fish being introduced into the system.

Further growth

39. At a weight of about 5g, fry are transferred to small ponds, plastic tanks or concrete raceways which are typically 0.3-0.6m in depth. Having attained a weight of about 40g, the fish are transferred, often by fish pump, to ponds, concrete raceways or circular tanks (up to 10m in diameter and 1-1.3m in depth).

40. Facilities for growing trout vary greatly although the most popular systems are Danish style earth ponds, concrete and brickwork raceways and circular, self-cleaning tanks. Holding facilities should be of a design such that injury is not caused to the fish. Outdoor holding facilities are generally protected

by a frame of netting to prevent predation (see paragraphs 222-229). The requirements of trout for environmental stimulation are not fully understood and the relationships between these requirements and the welfare of fish could usefully be investigated.

41. Fish pumps are used to move fish around the farm through a large bore pipe. In some ponds, and especially in warm weather, oxygen levels are enhanced by the operation of aeration equipment. In some raceways the use of parallel systems can reduce the likelihood that fish will be kept in water of too low a quality. Dead or moribund fish are usually removed using hand-held nets. On some farms we noted that older fish were being reared in the outflow channel of raceway systems. There is potential for the welfare of these fish to be poor if the water is not of adequate quality.

42. Trout are fed proprietary pellets of appropriate size by hand, by automatic food dispenser or by demand feeder operated by the fish. The practice of feeding by hand at some time each day is welcomed as it affords a good opportunity to assess the welfare of the fish. Automatic equipment must be checked frequently and properly maintained.

Recommendations: trout

43. When siting a trout farm the producer must take all reasonable steps to ensure that an adequate water supply of suitable quality will be available for all fish at all times.

44. Water supplies for trout hatcheries, whether ground water or not, must be suitable for the fish in terms of the temperature, dissolved gas content, pH, chemical quality, sediment levels and levels of pathogens and parasites.

45. The design of farm facilities should take account of welfare issues and, in particular, ensure that injury is not caused to the fish.

46. Outdoor holding facilities should adequately protect the fish from predators .

47. The requirements of trout for environmental stimulation should be investigated.

48. Automatic equipment such as water pumps and aeration systems must be monitored and incorporate alarms to indicate malfunction. Automatic feeding systems must be properly maintained and should be inspected daily.

49. Hatcheries, equipment and tanks, and further growth facilities should be properly cleaned and disinfected between batches of eggs or fish. Earth ponds should be emptied of fish and water and left fallow at suitable intervals.

50. An adequate method for daily removal of dead and moribund fish from tanks, ponds and raceways must be available (see also paragraph 64).

51. Fish should only be kept in the outflow channel if the quality of the water there is high.

STOCKMANSHIP AND INSPECTION

SALMON AND TROUT

52. The aim of good stockmanship is to provide an environment in which farmed fish can survive and grow and in which they can be free from disease, disorders, injury and distress. This may be achieved by employing suitably trained and experienced staff, following good working practices and maintaining equipment. Distress to the fish should be minimised by closely monitoring the fish and their

environment, to ensure that any problems or early signs of poor health or welfare are identified and acted upon swiftly.

53. It follows that farmed fish should be managed by an adequate number of trained and experienced staff who should be able to recognize signs of disease or disorder and maintain the environment in such a way as to provide for good health and normal behaviour. Aquaculture training should deal specifically with the welfare of farmed fish and all staff should be made aware of the importance of welfare as an integral part of the production process. Where possible, training should be validated by encouraging trainees to enter schemes such as the National or Scottish Vocational Qualification.

54. Fish, particularly young fish in hatcheries, may easily be unsettled, especially by the sudden movements of farm staff. To minimise fear responses, fish should be given appropriate experience of the proximity of staff. This can be achieved during feeding by exposure to people who should behave calmly so as not to frighten the fish. It may also be worthwhile to provide tank-side screening in hatcheries. This will offer shelter and limit disturbance when staff walk past tanks. It is less easy to condition salmon in large sea cages but exposure to the stockmen at feeding time and during inspection helps.

55. Fish in holding units must be closely inspected at least once a day, unless this is impossible due to adverse weather conditions. The inspection should focus on signs of good health such as correct orientation and swimming, the absence of visible signs of parasites, fungal or bacterial infections and any injuries. A sample of individual fish should be examined where a general inspection indicates that this is necessary, e.g. where poor body, skin, eye or fin condition is detected or where abnormal behaviour is displayed. Examination of individuals should ideally be undertaken in water to reduce handling and stress. Where handling and removal of the fish from the water are necessary the time period must be kept to a minimum. If fish are apparently not in good health, or are showing abnormal behaviour, the person responsible for their care must act promptly to establish the cause and take remedial action, if necessary with the assistance of a veterinarian or other expert. Any dead or dying fish must be removed promptly without adversely affecting the welfare of those remaining. Daily removal of dead and moribund fish should occur except when this might involve danger to personnel who work on sea cages.

56. Water quality should be assessed; with sufficient frequency to avoid poor welfare in fish, visually and with oxygen meters and chemical testing, particularly in shore-based facilities. An alarm should alert farm staff to unacceptable conditions. Where there are signs of poor water quality, such as faeces on the surface or in suspension and foamy or discoloured water, the problem must be remedied quickly. Poor water quality can also be detected from the disposition of the fish in the water and their behaviour e.g. grouping near to aeration equipment would indicate low oxygen levels.

57. FAWC attaches considerable importance to the maintenance of accurate records to aid the stockman and those enforcing animal welfare legislation. The responsibility for keeping on-farm records must lie with the person in charge of the fish. It is a legal requirement for fish farmers to keep records of live fish movements onto and away from a farm (Disease of Fish Acts (1937, 1983)). There is also a legal obligation to keep records of mortalities (Registration of Fish Farming and Shellfish Farming Business Order 1985 (as amended)) and of medicines used. In the interests of good management, records regarding feeding, numbers and weight of fish, stocking densities, growth, stock origins and water quality measures, where these are limiting, should be kept.

Recommendations: salmon and trout

58. Fish farms should be managed by an adequate number of suitably trained and competent persons.

59. Aquaculture training at colleges etc. should include the welfare of farmed fish.

60. The industry should pursue training schemes which are validated.

61. Whenever possible, fish should be conditioned to the proximity of farm staff so as to reduce fear responses.

62. Where handling is necessary for the purposes of inspection, this must be kept to a minimum.

63. Where welfare problems are discovered remedial action must be taken promptly and, if necessary, with the assistance of a veterinarian or other expert.

64. Dead and moribund fish must be removed daily except when this might involve danger to personnel who work on sea cages.

65. Water quality should be assessed frequently both visually and by the use of monitoring equipment which must be fitted with alarms to alert staff to unacceptable conditions. Staff should be available to respond to alarms which indicate a potential risk to the fish and should take appropriate action if emergencies arise.

66. Fish farmers must record live fish movements onto or off the site, fish mortalities and medicines used.

67. In the interest of good management, producers should record details of feeding, numbers and weight of fish, stocking density, growth and water quality measures, as unexpected changes may indicate a welfare problem.

68. Records should also be kept of any maintenance carried out and of generator and alarm tests.

FEEDING

SALMON AND TROUT

69. In contrast to mammals and birds, individual fish may show a very wide range of growth rates, matched to correspondingly wide differences in food intake. Within a natural group of salmon or trout in a stream, individual fish may show variations in growth rate both as a result of their own feeding preferences and variable feeding opportunities. Salmon which smolt in the wild, at about 125mm body length, may be between 1 and 4 years old. It is not uncommon for salmon and trout in the wild to survive long periods of food deprivation, for example over winter. During the return migration in freshwater, adult salmon may cease feeding altogether for periods of up to one year.

70. Farmed salmon and trout may also show wide variations in feeding and growth rates but, in general, they are fed regularly, at least daily, and grow at rather faster rates than fish in the wild. Food provision may be reduced at times to regulate growth or to reduce the fat content of the tissues and may be withheld altogether prior to transport or slaughter, or as a treatment for disease.

SALMON

71. The design of feeding systems and the methods used to distribute food should be such that an adequate quantity of food is made available to all fish. Food delivery points are normally spread over two dimensions, or are even concentrated in one place, but the fish are distributed in three dimensions. Individual salmon grow at different rates. However, little is known about the effect of spatial distribution of food and the relationship with growth rate and welfare. It is known that fish can be intimidated by others and that this can reduce feeding opportunity. Fish on the periphery of a cage, near the sides or bottom, may receive less food but does this or their size affect their welfare? These questions should be the subject of research.

72. Many devices are available whereby food is automatically delivered to fish in their holding facilities. Essentially a hopper filled with feed is provided with a mechanism that discharges set volumes at predetermined intervals. The mechanism may be driven by clockwork or electrical motors. Where electricity is needed a mains supply may be used (e.g. hatcheries) or power may be obtained from batteries (e.g. sea cages). Wind power may be used to drive a generator to maintain the charge of batteries or they may be routinely renewed and recharged ashore. Most automatic dispensers fan out the feed to distribute it over a relatively wide area to make food available throughout much of the tank or cage. Other hoppers discharge directly into the water below. Occasionally the timing system may be replaced by a rod which the fish may activate to feed on demand. In another type of system feed delivery is regulated electronically at a large central silo and carried by compressed air through pipes leading to each cage.

73. Feeding by hand remains popular as it allows a better evaluation of fish response and the choice of how feed is spread but it is labour intensive. Depending on the size of the fish, six to eight feeds may be given per day (post-smolt) but this regime would usually coincide with a feeding period from 05:00 to 22:00 hours, using two shifts of workers. With growth of the fish the ration size is increased but food is given less frequently; large salmon may be fed only twice a day but the hours of daylight available may extend the frequency. Manual feeding cannot be carried out if weather prevents access to the cages but in such conditions the fish lie low in the cages and may not respond to feed. After such a spell an enhanced ration may be fed but this will be a local management choice.

74. The feed is usually in a pellet form ranging from "crumb" size for fry through a selection of sizes up to 10mm diameter pellets for the biggest fish (broodstock). Fry should be carefully monitored during early feeding as this is a crucial stage in their development. Once the fry start to feed the aim is to maximise growth for the largest number of potential smolts. The proprietary feeds are a mixture of fish meals and fish oils with binders and possibly a cereal content such as bran. The proportions of these ingredients are varied according to circumstances. The pellets are classed as having normal, high or super fat content. Some farms produce their own feeds on site from commercially caught fish and can determine their own mixtures. Vitamins, trace elements, pigments and growth enhancers may also be included. Pellets sink into the water column or can be manufactured to float on the surface. Some producers use a wet feed system which introduces feed mixed with water through pipes into the cages.

75. To increase the probability of all fish receiving food it is necessary to grade them to reduce disparity caused by size, provide sufficient food for all fish, offer the correct size feed and regulate stocking density.

76. Fish are deprived of food before certain essential management procedures are carried out (e.g. prior to transport, treatment of disease and transfer of smolts from fresh water to sea water). The objectives of food deprivation are to evacuate the fish's gut and to reduce oxygen demand and waste production in order to improve the welfare of the fish during the management procedure. Farmed fish should not be deprived of food for any other reason.

77. Smolts are deprived of food prior to transfer to sea primarily to reduce oxygen demand during transport. However, the stress associated with transport is reduced by lowering the fish's metabolic rate.

78. Before transport it is current practice to deprive fish of food for 48 hours, or longer under cold conditions when gut clearance rates are low. This practice reduces faecal contamination of water in the transport tank and minimises the metabolic load when the fish are crowded together for collection before and during transport.

79. Prior to slaughter, salmon are often deprived of food for some days or weeks. In the wild, salmon cease to feed prior to breeding and are adapted to food deprivation at this time. However, depriving a farmed fish which has been fed regularly will normally cause some adverse effect on welfare. Though controlled food deprivation can be beneficial it should not be carried out as a matter of course. In order that the overall effect of the food deprivation on welfare is an improvement, any beneficial consequence must be sufficient to counterbalance any direct adverse effects. Food deprivation as a means of redressing the adverse effect of feeding an inappropriate diet is unacceptable.

Recommendations: salmon

80. Feeding of fish should be such that the quality, quantity and frequency are optimal for their stage of development. The early feeding of fry and young fish should be monitored.

81. Food should be distributed evenly and widely so that it reaches the maximum number of fish. Better systems for the provision of adequate amounts of food to all fish should be developed.

82. Fish should not be totally deprived of food except during a period of up to 72 hours before slaughter for food hygiene reasons or where the overall effect of food deprivation is an improvement in fish welfare.

83. The period during which salmon may be deprived of food prior to certain management procedures must be kept to a minimum and should normally not exceed 72 hours.

84. There should be scientific research carried out on the interrelationships between food distribution, fish size and fish welfare.

TROUT

85. Feeding systems for trout are similar to those used for feeding salmon, either automatic or hand feeding. Trout also grow at different rates. As mentioned previously, little is known about the effect of spatial distribution of food and the relationship with growth rate and welfare. It is known that fish can be intimidated by others and that this can reduce feeding opportunity. Some fish may receive less food than others and the question asked in relation to salmon is equally pertinent to trout: does this or their size affect their welfare? This should be the subject of research.

86. Trout are fed proprietary diets in pellet form all their life . The pellets range in size from coarse powders for fry to 10-20mm pieces for adult fish. The pellets contain animal protein, oils and vitamins and are balanced with inert plant fibre filler. Additional vitamins, hormones, antibiotics and vaccines may also be incorporated into the pellets. Floating or slow sinking pellets are distributed by hand, by automatic feeder or by a combination of both.

87. Feeding levels follow guidelines laid down by the feed manufacturers to achieve good conversion efficiency. Early diets tend to be of higher calorific value (with more oil) than diets for older growing fish or for broodstock. The monitoring of early feeding by fry is important.

88. Trout are deprived of food prior to slaughter and before significant handling and transport procedures. The objective of food deprivation is to evacuate the fish's gut to improve the welfare of the fish during the necessary management procedures. Fish should not be deprived of food for any other reason. In warm weather trout may reduce their intake or stop feeding altogether so the amount of food provided should be decreased accordingly to avoid water quality problems.

89. Before transport it is current practice to deprive fish of food for 48 hours, or longer under cold conditions when gut clearance rates are low. This practice reduces faecal contamination of water in the transport tank and minimises the metabolic load when the fish are crowded together for collection before and during transport.

90. Prior to slaughter, trout are often deprived of food for some days. Depriving a farmed fish which has been fed regularly will normally cause some adverse effect on welfare. Though controlled food deprivation can be beneficial it should not be carried out as a matter of course. In order that the overall effect of the food deprivation on welfare is an improvement, any beneficial consequence must be sufficient to counterbalance any direct adverse effects. Food deprivation as a means of redressing the adverse effect of feeding an inappropriate diet is unacceptable.

Recommendations: trout

91. Feeding of fish should be such that the quality, quantity and frequency is optimum for their stage of development. It is important to monitor the early feeding of fry and young fish.

92. Food should be distributed evenly and widely so that it reaches the maximum number of fish. Better systems for the provision of adequate amounts of food to all fish should be developed.

93. Depriving trout of food prior to certain management procedures should be to achieve gut evacuation and not to adjust body composition, and the period should normally not exceed 48 hours.

94. Trout should not be totally deprived of food except during a period of up to 48 hours before slaughter for food hygiene reasons, or where the overall effect of food deprivation is an improvement in fish welfare.

95. There should be scientific research carried out on the interrelationships between food distribution, fish size and fish welfare.

PRODUCTION LIFE CYCLE

SALMON

Breeding

96. FAWC recognises the potential for poor welfare during the assisted breeding processes of stripping and milking but believes that during general management there is an economic pressure to ensure that the welfare of broodstock is good.

97. Female broodstock, usually kept for two or three winters at sea, are selected for breeding. They are generally removed from their sea cages into tanks of either freshwater or seawater approximately one month before stripping (extraction of eggs). These fish are closely monitored for ripeness. The monitoring comprises light sedation by administration of a controlled concentration of anaesthetic to facilitate handling and palpation of the abdomen to see if the egg mass is free. Some fish may undergo this process several times, usually two or three days apart. The main anaesthetics used are benzocaine (dissolved in a solution of acetone), phenoxyethanol and MS222.

98. Females which are found to be ready for stripping are anaesthetised by immersion in a tank containing anaesthetic solution. When fully anaesthetised, the fish are washed in clean water (to remove anaesthetic) before stripping. Stripping of anaesthetised fish may be solely by hand or with the assistance of compressed air introduced into the body cavity of the fish by means of a needle to ensure effective egg retrieval. Surgical removal of the ovaries is also occasionally employed.

99. Females are usually killed after stripping. This is normally achieved by a sharp blow to the head before recovery from the anaesthetic. A small minority of producers allow hen fish to recover after stripping so that they can be used again in subsequent years. However, because the time to regain body condition can be over a year, most farmers consider this uneconomic.

100. Male fish are generally anaesthetised before milking (extraction of milt), a process which may be repeated several times prior to slaughter. There is usually a recovery period of about three days between milkings. The male fish are normally killed in a similar way to the females. The broodstock carcasses are not suitable for human consumption because of the exposure to anaesthetic. The trade in salmon roe may become active in the UK, as it is elsewhere, in which case the treatment of the fish should not adversely affect their welfare, e.g. they should be killed before the roe is removed.

101. Personnel using anaesthetics for the purpose of stripping eggs and milt from fish should be trained and competent in their use and recognise the stages of anaesthesia in the fish. Written guidance should be followed where given by the manufacturer.

Recommendations: salmon

102. During the stripping and milking processes the number of times a fish is handled and exposed to sedation should be minimised to avoid undue skin injury and stress.:

103. If live fish are stripped an effective anaesthetic must be used, and must be maintained at the correct concentration throughout the procedure.

104. Where compressed air is used to assist stripping in live fish they must be fully anaesthetised.

105. *The stripping and milking processes should be carried out by fully trained and competent personnel.*

Hatchery

106. Fertilisation takes place in a bowl or a bucket. The products of the male and female fish are kept in separate dry containers, the eggs with their attendant ovarian fluid. The sperm are checked for motility, by adding fresh water to a sample on a microscope slide, and then added to the bowl containing the eggs. Eggs should be disinfected following fertilisation but before water hardening.

107. After 250 degree-days, when they become 'eyed', the eggs are physically shocked. This is done by removing the eggs from the incubator and pouring them, without water, into a dry bucket allowing a fall of about 50cms. The infertile eggs then become white, and these can be removed by manual picking or automatic egg sorting machines. It is essential to inspect the eggs at frequent intervals for signs of fungal infestation. Good flows of clean, well-oxygenated water must be maintained throughout the cycle. Heated water can be used to speed up the development of the eggs. Heating is expensive and rather than letting the water flow to waste it is often recycled. This operation requires various systems to ensure the purity of the water; such as settlement tanks, ozone treatment and UV irradiation. At about 300 degree-days the eggs begin to hatch and hatching is completed within two or three days. Debris and unhatched eggs should then be removed.

108. For about a further 300 degree-days the alevin will survive and develop by utilising the yolk sac. Normal practice in the industry is to minimise energy utilisation, for example by using an artificial substratum (such as Astroturf) which gives the alevin something to lean against so that it does not need to swim upright. Alevins are negatively phototactic and are generally kept in the dark. If a light is switched on a burst of activity can be seen. Care must be taken if alevins are moved as the timing of first feeding is crucial and losses can be high if moves are mistimed.

109. As the alevins use up the last of their yolk sac and begin to feed they are termed 'fry'. The fry will grow to about 5g when they will develop the characteristic spots of the salmon and parallel ovoid markings on the flanks. This stage is called the 'parr'.

110. At several months old, parr are usually moved into outdoor tanks. The exact age varies in different production units and a few producers keep parr inside until they are actually transferred to sea cages as smolts, at which stage they are adapted to sea water. Water is continuously pumped through the tanks, ensuring a constant fresh supply and thus discouraging the build-up of any contaminated matter. Outdoor holding facilities should have some form of protection, for example netting, against predation (see paragraph 30).

Recommendations: salmon

111. Eggs should be inspected soon after fertilisation and frequently thereafter for signs of fungal infestation.

112. Fry should be inspected regularly, preferably daily, for signs of disease and parasites. Where these are detected there should be rapid investigations and suitable treatment should be instigated promptly.

113. High standards of hygiene must be observed within hatcheries to prevent the transmission of disease.

114. There must be an adequate supply of water of a quality that is suitable for the fish.

115. The stocking densities in hatcheries should allow for adequate oxygen provision for each fish.

Further growth

116. Salmon parr become smolts naturally between March and May but the process can start much earlier. The smolts are then moved to sea. They are more easily damaged during transport and more susceptible to fungus if they are maintained in freshwater. Smolts that go to sea after one year are called S1s and may weigh anything between 30 and 120g. Parr that do not smolt and are held for a further year are called S2s and may weigh up to 400g going to sea. There is a small but increasing production of S½s, which are induced to smolt in the autumn by using temperature and photoperiod control.

117. Almost all further growth takes place in sea water cages. During this period the main priority is to achieve optimal growth. Feeds may vary but the most common feed consists of a dry pellet with a high oil content (25-30% oil) (see paragraph 74).

118. Stocking densities are a crucial factor affecting fish welfare. A balance must be struck between optimising the use of cages and the needs of the fish. Fish need sufficient space to show most normal behaviour with minimal pain, stress and fear. Some of the fin injury which was evident in most of the salmon we observed may be a consequence of stocking densities which were too high. Farmers formerly aimed for a maximum density of about 25-30kg/m^3 in sea cages but recent practice has been to aim for a maximum of about 15kg/m^3 because this reduction helped to limit the impact of disease. The actual figure chosen is dependent on local conditions but the trend towards lower stocking densities is welcomed. However, it was noted that this reduction was part of a strategy to control disease and that as farmers make more use of vaccines there may be a temptation to increase stocking densities. In cages which were studied carefully, smaller fish have been observed to adopt peripheral positions and this may occur generally. Some fish can be prevented from feeding and forced to take evasive action by more dominant fish. Good scientific information concerning the effects of stocking densities on welfare is lacking, but in the absence of this, high stocking densities must be avoided until it can be demonstrated that they do not have harmful effects on fish.

119. Apart from movements between cages to group fish of similar sizes following grading, fish will normally remain in the same cages at sea until harvest. This may be anything from one to three winters at sea depending upon the maturity of the fish and the size required at slaughter.

120. Salmon mortality after the parr stage can be much higher than that which occurs in other farmed animals. High mortality is likely to be associated with poor welfare and efforts should be made to reduce it in existing management systems and to develop systems which improve fish welfare and reduce mortality.

Recommendations: salmon

121. The stocking density must allow fish to show most normal behaviour with minimal pain, stress and fear. Pending scientific research on the welfare of salmon in sea cages, 15 kg/m³ should be considered as an acceptable stocking rate. Higher densities may also be acceptable for short periods prior to slaughter and during treatment for disease and parasites.

122. Research should be undertaken urgently to determine acceptable maximum stocking densities taking account of factors referred to in paragraph 120 and including objective measures of the welfare of the fish. These results should be available within five years, at which point we expect to recommend the introduction of legislation to limit stocking densities.

123. Efforts should be made to reduce mortality between the parr stage and slaughter by improving existing management systems and developing systems which are better for fish welfare.

TROUT

Breeding

124. As with salmon there is the potential for poor welfare during the stripping and milking processes with trout but broodstock management is economically important and care is usually taken with fish handling. Other reproductive techniques such as induced triploidy and all-female production may have an effect on welfare but this is not known at present.

125. Most broodstock are two to five years old. They are valuable and are housed in conditions better than those for fish destined for slaughter. Spawning is seasonal with some stocks maturing in autumn, others in spring. Fish are examined for maturity by handling with or without anaesthesia. On ovulation, eggs drop into the abdominal cavity. They are hand stripped from the hen fish by gentle stroking of the abdomen from head to vent once the fish are fully anaesthetised. When stripping is complete, the hens are returned to a pool where they slowly recover from anaesthesia.

126. Males may be stripped of milt in a similar way but sex-control practices, now commonly used, require that the fish are humanely killed (see paragraphs 250-253) prior to surgical removal of the gonads. A range of anaesthetics is used to calm the fish before handling. Most operators use rough guidelines for concentrations modified by the way fish respond on the day and dependent on environmental factors.

Recommendations: trout

127. During the stripping and milking processes the number of times a fish is handled and exposed to sedation should be minimised to avoid undue skin injury and stress; effective anaesthetics must be used and these must be maintained at an effective concentration throughout sedation and anaesthesia.

128. Where compressed air is used to assist stripping in live fish they must be fully anaesthetised.

129. The stripping and milking processes should be carried out by fully trained and competent personnel.

130. Male trout must be humanely killed before removal of their testes.

Female-only technique

131. This technique is used to produce female fish only, avoiding the production of males which perform poorly and which can become sexually mature in less than one year. To start the process the male hormone, methyl testosterone, is introduced into fry food; this turns all these fish into males. Those fish which would have been males anyway are identified by the presence of males in their subsequent offspring and they and their offspring are not used in production. On the other hand the male fish which, without the hormone treatment would have been females, produce only female offspring when mated with females. This technique is now commonly used and each year a small group of female fry is set aside for masculinisation so as to provide males for continuing the line. In effect the Y chromosome (male determining) has been eliminated from the stock.

Recommendation: trout

132. The use of hormones in sex inversion must be carefully controlled, under veterinary supervision, and should be carried out by fully trained and competent personnel.

Induced triploidy

133. This technique is used for production reasons to produce sterile fish which have three sets of chromosomes instead of the normal two. The process generates an embryo with two sets of maternally derived chromosomes and one set from the male parent. This is achieved by subjecting the egg to hot, cold or pressure shock just after fertilisation. Heat or pressure shock is used for trout. In combination with the female-only technique the triploid technique produces sterile female fish and is commercially advantageous. The technique can also be used for salmon.

Recommendation: trout

134. Shock treatment of eggs, which is used in the production of triploid fish, should be employed only by fully trained and competent personnel.

Hatchery

135. Eggs and milt are mixed without water but washed clean a few minutes later. The fertilised eggs harden within 20 minutes or so and are then placed in a layer in trays or en masse in funnels. In the former case, dead eggs can be removed by hand although care must be taken to avoid damage to adjacent eggs. This it not feasible with funnels and we were informed that fungal infection is controlled by regular flushing with malachite green (see paragraph 217). Eggs must have a continuous flow of well-oxygenated water and must be shielded from bright light. They hatch in a few weeks depending on species and temperature and for a similar period lie more or less inactive whilst absorbing the contents of the yolk sac. When this is almost complete, the fry 'swim-up' and are fed fine particles of proprietary high protein food. This stage is critical and should be monitored carefully. Hygiene in the trays or troughs is important but farmers say that malachite green remains the main treatment for fungal contamination.

136. There is some evidence that fish fry need space for movement, exploration and interactions with each other but at a minimum the stocking density must allow adequate oxygen provision.

Recommendations: trout

137. Eggs should be inspected soon after fertilisation and frequently thereafter for signs of fungal infestation.

138. Fry should be inspected regularly, preferably daily, for signs of disease and parasites. Where these are detected there should be rapid investigation and suitable treatment should be instigated promptly.

139. High standards of hygiene must be observed within hatcheries to prevent the transmission of disease.

140. There must be an adequate supply of water of a quality that is suitable for the eggs and fry.

141. The stocking densities in trout hatcheries should allow for adequate oxygen provision for each fish.

Further growth

142. Fry leave the hatchery at a size of about 5g for distribution to farms. They are transported in specially designed tankers fitted with oxygen monitoring equipment and aeration or oxygenation apparatus. Larger fish are also transported in this way. Some farms start with fish of 50 to 100g in weight and, for stocking fisheries, fish may be up to 1 kg in weight or more when released. Trout reared for the table are killed at approximately 350-400g.

143. On our visits we saw trout stocked at levels up to 60kg/m^3 although the more normal range was between 30-40kg/m^3. During the visits we noted a high incidence of fin injury which suggests that stocking density may be too high in all trout farms. It is a highly complex task to set a maximum stocking density for trout because of the variety of systems in use. Many factors such as oxygen level, fish size, water temperature, water flow, available space and carbon dioxide and ammonia levels affect the acceptability of stocking densities. We note these difficulties but believe that work needs to be done urgently to determine a maximum acceptable stocking density for trout. It has been difficult to discover the mortality rate of farmed trout but it is higher than that which occurs in other farmed animals. High mortality is likely to be associated with poor welfare and efforts should be made to reduce it in existing management systems and to develop systems which improve fish welfare and reduce mortality.

Recommendations: trout

144. The stocking density must allow fish to show most normal behaviour with minimal pain, stress and fear. Scientific research is needed on the effect of stocking density on fish welfare but it seems that 30-40 kg/m^3 is too high a stocking rate for trout. Higher densities may be acceptable for short periods prior to slaughter and during treatment for disease and parasites.

145. Research should be undertaken urgently to determine acceptable maximum stocking densities taking account of factors referred to in paragraph 143 and including objective measures of the welfare of the fish. These results should be available within five years, at which point we expect to recommend the introduction of legislation to limit stocking densities.

146. Efforts should be made to monitor trout mortality accurately and to develop management methods and stocking densities which reduce it.

HANDLING, GRADING AND TRANSPORT

SALMON AND TROUT

Handling

147. Removal from water and handling are stressful to a fish, eliciting a maximal emergency physiological response, nevertheless it may be advantageous and necessary for good welfare. Where handling is necessary it should be carried out by the least stressful method available and sedation may be appropriate. Where hand-nets are used to handle fish they should present a smooth surface to the fish. Fish taken from water are out of their natural environment and adequate support must be given particularly when dealing with large, heavy fish; they should not be held up by the tail. Indications of poor handling include fin and skin injury and scale loss, to which salmon smolts are particularly susceptible.

148. Procedures and equipment should be designed to minimise injury. Personnel carrying out any handling procedures should have adequate training to avoid undue stress and injury to the fish. Handling frequently involves crowding but must be carried out so that there is adequate oxygenation of the water.

149. In general, the longer the period of stress the greater the injury and mortality, thus reducing the time taken in handling fish will encourage a more rapid recovery. The use of vacuum pumps to move fish around the site is common and some sectors of the industry have expressed a preference for this method because there is less injury to the fish.

Recommendations: salmon and trout

150. Handling equipment and procedures should be designed to minimise stress in the fish.

151. Handling equipment should be properly maintained.

152. Fish should be handled by trained and competent personnel only.

Grading

153. Salmon are graded a number of times before becoming smolts. This is carried out to prevent aggression and cannibalism by faster growing fish on those smaller than them. If there are large size differentials the larger fish may act aggressively and territorially and prevent the smaller ones from feeding. Smolts may be graded five or six times prior to transfer to sea cages at one year and further grading may be required for those fish which take two years to become smolts.

154. Trout may be graded several times during their lifetime. Fry will usually be graded twice before the fish, as fingerlings, are transferred to growing tanks or raceways. During the first few months, grading in trout is done to prevent cannibalism. Thereafter it is carried out for production reasons.

Grading machines

155. Automatic grading machines vary in construction and fish can be netted into the grader, pumped in by vacuum pump, or moved in by means of a screw elevator. The grader separates the fish by size usually by allowing them to travel along a slowly widening "V" shaped conveyer. The fish drop through the widening gap into one of several outlets from where they are conveyed, usually by tube, to different tanks for further growth. Many graders will have an automatic counter built in to each of the outlets. The total time taken for a fish to travel from the pump through the grader and back to the tank

can be as little as two to three minutes. Depending on the system, the fish are either immersed or sprayed with water throughout the operation. Passive grading is sometimes used whereby smaller fish are able to move through a grid of a specific size into a different tank or container. This method does not ensure that all the small fish swim through nor does it count them.

Recommendations: salmon and trout

156. Grading equipment and procedures should be designed to minimise stress and injury.

157. Automatic grading equipment must be regularly maintained and an alarm fitted to alert staff in the event of breakdown.

158. Fish populations should not be graded more often than is absolutely necessary since most kinds of grading are likely to be stressful for fish.

Transport

159. The vast majority of trout transported within the UK travel by road in tanks placed on flat bed vehicles. An oxygen supply is also carried and concentrations are constantly monitored and maintained at an appropriate level. Information is relayed automatically to the driver who has the facility to adjust oxygen levels from the cab of the vehicle. Fish are loaded into, and unloaded from, their transport containers either by use of vacuum pumps or by hand with the use of nets. These nets should be designed so that they do not injure the fish. Salmon smolts, when transferred from fresh water to sea cages, are transported either in a purpose-designed tank slung below a helicopter, by road similarly to trout, or by sea in specially designed well-boats. Adult salmon are sometimes transported live from their sea cages in well-boats for slaughter.

160. Fish in transit should be inspected regularly. It is essential that oxygen levels in transport tanks are maintained at above 6 mg/l, carbon dioxide levels are kept low and excessive changes in water temperature and pH are avoided. Delays in transport should be minimised to reduce the risk of adverse conditions developing.

161. Before transport it is current practice to deprive fish of food for 48 hours, or longer under cold conditions, to achieve gut clearance. This practice reduces faecal contamination of water in the transport tank and minimises the metabolic load when the fish are crowded together for collection before and during transport. The period of crowding prior to transport should be kept to a minimum.

162. Care should be taken to ensure that dead fish are not loaded for transport. Any which die in the course of the journey should be separated from the live fish on arrival with a minimum of delay. Transport containers should be cleaned and disinfected after conveyance of each consignment of fish to prevent the spread of disease.

163. Under the Diseases of Fish Acts (1937, 1983) all farm sites are obliged to record all movements of live fish, fry and eggs onto and off the site. The purpose is to trace possible origins of infection and is not directed to the welfare of the fish. The Welfare of Animals during Transport Order 1994 (as amended) states that a record must accompany the fish during transport stating, amongst other things, the origin and ownership of the fish; the place of departure and place of destination; and the date and time of departure. The Fish Health Regulations 1992 (as amended) prohibit the loading of fish showing clinical signs of disease, and require that the means of transport must be cleaned and disinfected prior to despatch. They also require that the duration of the journey be as short as possible; that water cannot escape from the transport vehicle; that all reasonable steps should be taken to safeguard the health of the fish, including, if appropriate, changing the water in which they are transported; and that water used should be changed only at an approved water station.

Recommendations: salmon and trout

164. The welfare of fish in transit by road should be checked at intervals not exceeding four and a half hours, the duration before which a commercial driver is obliged to take a break under road traffic legislation.

165. Fish in transit should be in conditions which will allow them to survive a journey at least 50 per cent longer than the anticipated duration.

166. Both the salmon and trout industries should give consideration to the need for Codes of Practice on transport which refer directly to fish welfare.

167. Crowding before collection for transport or killing should not be so prolonged or severe that unnecessary suffering is caused.

168. Oxygen levels must be constantly monitored and drivers should have the facility to adjust levels from the cab. Carbon dioxide should not be allowed to rise to levels which harm the fish.

169. Excessive changes in water temperature and pH in transport tanks must be avoided.

170. Transport containers should be cleaned and disinfected after conveyance of each consignment of fish.

171. Fish must be checked before transport and unfit or unhealthy fish must not be transported.

172. We endorse the requirement of the Welfare of Animals during Transport Order 1994 (as amended) that a written record must accompany fish during transport.

173. Nets used for catching and handling fish must not injure the skin or fins of the fish, for example they should be knotless.

DISEASE AND PARASITISM

SALMON

174. Losses in salmon farming are often due to disease. These diseases are classed as parasitic, bacterial, viral or fungal. The high stocking densities of fish in aquaculture render them particularly susceptible to disease and parasites. Moreover, most waters are populated by wild fish which may carry and be susceptible to disease agents, and steps have to be taken to minimise the likelihood of disease outbreaks in the farmed stock.

175. There is a wide variety of diseases which can affect salmon. In fresh water, fungi and protozoan parasites are the greatest threat. Eggs are particularly susceptible to fungal infection so treatment with fungicide is necessary. We are told that malachite green is the agent which provides the most effective control. Similarly, ectoparasites can be controlled with formalin or formalin combined with malachite green (see paragraph 217). Bacterial diseases such as furunculosis, caused by *Aeromonas salmonicida* and enteric redmouth (ERM), caused by *Yersinia ruckeri*, are usually treatable with antibiotics. Bacterial kidney disease (BKD), caused by *Renibacterium salmoninarum*, is rare but at present there are no effective antibiotic treatments and the impact of the disease in individual cases may be serious. Infectious pancreatic necrosis (IPN) is a viral disease and untreatable at present. In sea water the three major problems of concern are (i) pancreas disease, (ii) sea lice and (iii) furunculosis all of which can cause very considerable welfare problems and economic loss. Other problems may include IPN, vibriosis and, in rare cases, BKD.

176. Furunculosis avoidance is a major factor affecting fish management. The introduction of new and efficacious injectable vaccines to prevent furunculosis has shown encouraging signs of success and

vaccines have largely superseded antibiotic treatment which was becoming less effective due to the development of resistant strains of the causal agent *A. salmonicida*. Although oral administration of vaccines is still a relatively new technique, the development of oral vaccines could improve welfare by reducing handling. Vaccines which protect against several diseases are desirable because they further reduce handling.

177. Sea lice, which erode the skin causing tissue damage, have traditionally been controlled using dichlorvos and more recently hydrogen peroxide. However, the development of resistance by some sea lice has reduced the effectiveness of dichlorvos. Concern has also been expressed about possible effects of dichlorvos on the marine environment. Wrasse are small fish which clean parasites off large fish and they are also used to help control sea lice on farmed stock (see paragraphs 208-213). They may be eaten by large fish. The development of an effective vaccine against sea lice could significantly contribute to improving welfare.

178. Pancreas disease is caused by a virus and can cause loss of weight or emaciation. Affected fish may be more susceptible to other diseases and treatment of these diseases may be less effective. At present, control of disease relies upon husbandry practices and the impact can to some extent be alleviated by modifying feeding regimes. The development of an effective vaccine could significantly improve welfare.

179. Salmon farmers should try to minimise stress by avoiding handling and keeping stocking densities down (see paragraphs 121-123). Site selection is equally important and operators should keep year classes on separate sites to avoid cross infection. Leaving sites fallow, entering into management agreements with several operators in a given area, removing all fish before restocking, and exchanging disease information are useful methods of limiting disease. There are also environmental reasons for fallowing. Implementation of such changes has led to an improvement in fish survival and growth.

180. British legislation requires certain diseases to be reported to the responsible authority (MAFF or SOAEFD). There are eight such notifiable diseases and several categories of seriousness are recognised by the European Union. List I diseases are exotic to the EU: the viral disease infectious salmon anaemia (ISA) falls into this category. List II diseases have a limited distribution in the EU. There are two list II diseases at present, infectious haematopoietic necrosis (IHN) and viral haemorrhagic septicaemia (VHS). IHN has never been found in Great Britain and VHS has been found only once, in farmed turbot, in 1994. List III diseases are considered to be less serious than list I or list II diseases or are treatable and endemic in the EU. Five list III diseases are notifiable in Great Britain - BKD, IPN in salmon, furunculosis in salmon, spring viraemia in carp (SVC) and gyrodactylosis (caused by *Gyrodactylus salaris*). *G. salaris* has never been found in Britain.

181. Farmers should familiarise themselves with the Fisheries Departments' leaflets "Guide to Importing Fish" and "Combating Fish Disease" which set out import rules and on-site control measures.

Recommendations: salmon

182. Aquaculture systems should be designed such that disease is minimised.

183. Fish in holding units should be inspected daily by experienced personnel for signs of disease in the stock and any necessary action must be taken immediately.

184. The industry should endeavour to develop better methods of inspecting fish to recognise those which are diseased, distressed or dead.

185. During an outbreak of disease where the cause of death is not immediately apparent, laboratory examination should be carried out to enable treatment to the remaining fish to be initiated.

186. Health certified or vaccinated stock should be used wherever possible.

187. Farmers should practice routine disinfection of equipment and clothing of personnel to reduce the risk of transfer of disease.

188. Leaving sites fallow will reduce the risk of disease or parasite transmission. Management agreements with other operators to fallow wider areas before restocking will reduce this risk level as will information exchange about disease.

189. Stocking density must be kept within manageable levels for the holding facilities.

190. Handling must be minimised so as to lessen susceptibility to disease.

191. Holding units should be cleaned and disinfected once all fish are removed.

192. Different year classes should be kept on separate sites to avoid cross infection.

193. National disease control should be maintained and outbreaks of any serious disease should be reported to the national authority.

TROUT

194. In the hatchery moribund or dead embryos and infertile eggs are quickly infected with fungus which can spread to healthy embryos if left unchecked. We understand that present control is by malachite green wash and removal of dead eggs. The latter is time consuming, possible only with a monolayer system, and can lead to the death of adjacent eggs by mechanical disturbance.

195. On leaving the hatchery, often with its bore hole water environment, for river water the fry become exposed to a wide range of pathogens and parasites. Fry anaemia is caused by the bacterium *Cytophaga psychrophila* which is not easy to control other than by strict attention to hygiene. Antibiotic treatments are occasionally effective. Protozoan infestations are frequently controlled at present by formaldehyde bath or formalin with malachite green (but see paragraph 217). Whirling disease which is caused by a sporozoan has no treatment but can be avoided by management measures. Non-specific gill irritation which is sometimes induced by high silt levels can be cleared by hyamine bath. Infectious pancreatic necrosis can be avoided by refraining from introducing fry in sites where it is present.

196. Adult fish are subject to a wide range of problems, some more serious than others. Endemic bacterial problems include enteric redmouth for which vaccines are available and bacterial kidney disease (which is notifiable) for which there is no effective treatment or vaccine. Cold-water diseases caused by *C. psychrophila* can also occur. We learned from trout farmers that parasite-induced proliferative kidney disease is a major economic problem on farms in the south of England and is currently controlled by use of malachite green, with or without stress reduction, and that external fungal infections can be controlled with malachite green. Eyefluke can be a problem and control by mollusc removal is the only remedy. Viral diseases include infectious pancreatic necrosis which causes few problems in larger fish, and two serious notifiable diseases which are important in other European countries: viral haemorrhagic septicaemia and infectious haemopoietic necrosis. Apart from these diseases, major losses still occur through accidental oxygen deprivation, hence the emphasis in this report on the prevention of such occurrences, and non-specific mortality of unknown aetiology.

Recommendations: trout

197. Aquaculture systems should be designed such that disease is minimised.

198. Fish in holding units should be inspected daily by experienced personnel for signs of disease in the stock and any necessary action must be taken immediately.

199. The industry should develop better methods of inspecting fish to recognise those which are diseased, distressed or dead.

200. During an outbreak of disease where the cause of death is not immediately apparent, laboratory examination should be carried out to enable treatment of the remaining fish to be initiated.

201. Health certified or vaccinated stock should be used wherever possible.

202. Farmers should carry out routine disinfection of equipment and clothing of personnel to reduce the risk of transfer of disease.

203. Fallowing sites will reduce the risk of disease and parasite transmission.

204. Stocking density should be kept within manageable levels for the holding facilities (see paragraphs 144-146).

205. Handling should be minimised so as to lessen susceptibility to disease.

206. Holding units should be cleaned and disinfected once all fish are removed.

207. National disease controls should be maintained and outbreaks of any serious disease should be reported to the national authority.

WRASSE

208. It appears that wrasse (cleaner fish) could be used in increasing numbers in the salmon industry to reduce sea lice as they are clinically, financially and environmentally beneficial. Attention should therefore be paid to factors essential to their welfare.

209. The welfare of wrasse should be carefully considered and guidelines have already been formulated by the salmon industry on the use of these fish. Particular emphasis should be paid to the importance of: (i) provision of refuges to give wrasse protection from bird predation and attack by large salmon, (ii) their removal before grading, (iii) their removal when depriving salmon of food prior to slaughter, and (iv) provision of food for them if insufficient is available from lice and cage fouling. Finally, wrasse suffering from disease should be destroyed in an humane and hygienic manner.

Recommendations: wrasse

210. Wrasse should be able to obtain refuge from predation by birds and attack by large salmon.

211. Wrasse should be removed from sea cages before or during the grading of salmon.

212. Wrasse should be removed from cages when food is withdrawn from salmon.

213. Food must be provided for wrasse if sufficient is not available from sea lice or fouling organisms.

AVAILABILITY OF VETERINARY MEDICINES

SALMON AND TROUT

214. Legislation and enforcement procedures within the EU and in the UK in particular ensure that companies may only place medicines on the market once they have been authorised following the consideration of scientific data demonstrating that they are of good quality, are effective when used according to label recommendations, and are safe. Safety includes the assessment of possible hazards to treated animals, other animals, people using the medicines, the environment and, where relevant, consumers of food from treated animals. However, our discussions with the fish farming industry indicate that present and proposed authorisation procedures for vaccines and veterinary medicines may result in some adverse effects on the welfare of farmed fish. It is important that the products of fish farming should be safe for human consumers but we share the concern expressed by the industry and animal protection societies that welfare may be adversely affected because efficacious medications are either not authorised or are not authorised quickly enough. It is also possible that new products may not be developed because of the high cost of generating the data needed for approval.

215. We have been told that in the application for marketing authorisations by pharmaceutical companies, fish are considered minor species. We understand that the data required for authorisation for each species are very expensive to obtain and the process is not usually cost-effective for minority species. It is hoped that data from major species can be used and that delays in authorisation can be minimised so as to encourage the timely application for new or existing products which would be effective for fish as well as other species.

216. A European Commission Regulation setting out Maximum Residue Limits (MRLs) for medicines is currently being implemented, and from January 1997, or a later date if agreed, the pharmacologically active ingredients must have an MRL. This could mean the loss of a number of medicines which are currently available, and this could result in serious welfare problems in the fish farming industry if the outstanding issues are not addressed.

217. The main drugs and chemicals used in the fish farming industry which do not have marketing authorisation for use and which need careful consideration are formalin, malachite green, chloramine, benzalkonium chloride, oxolinic acid, fenbendazole and benzocaine. Some of these ought not to be used without a veterinary prescription and are subject to a minimum withdrawal period of 500 degree-days. The fish farming industry might consider holding regular meetings with relevant sections of the pharmaceutical industry to liaise on disease and medicine developments.

Recommendation: salmon and trout

218. It is essential that the welfare of farmed fish is not adversely affected by limiting the availability of vaccines or therapeutic medicines which are known to be effective and do not pose a food safety or environmental hazard. Ways must therefore be found to achieve rapid availability of vaccines and medicines to deal with emergencies such as major outbreaks of disease, and also to increase the range of vaccines and medicines approved for the treatment of fish. Well-tried and efficient medicines must not be lost unless adequate alternatives are available.

MUTILATIONS

SALMON AND TROUT

219. Mutilations of farmed fish are relatively uncommon. They are limited to a few specialised areas of the industry, where individual fish, or populations of fish, are marked, so that they may be distinguished from one another. Such areas include broodstock production, selective breeding

programmes and other areas of research and development such as vaccination or feed trials. Fin clipping, whereby part of one of the fins, usually (in salmonids) the adipose fin, is cut off is sometimes carried out. So is external tagging which involves the attachment of a small plastic tag bearing a unique identifier to the body, the fins or the gill cover. Other methods employed include dyeing of the skin and insertion of micro-tags into insensitive tissue.

Recommendations: salmon and trout

220. In principle FAWC is opposed to the unnecessary mutilation of farmed animals solely as an aid to management. Mutilations which involve removal of sensitive tissue should not be carried out on farmed fish.

221. Marking methods should be used only where they cause minimal damage to the fish.

PREDATORS

SALMON AND TROUT

222. Fish farms can suffer considerable losses as a result of predator activity. The principal predators are seals, otters, mink, herons, cormorants, shags and other seabirds.

223. Methods of control include top netting of entire farms or net coverings for individual tanks and raceways in trout farms and similar top netting of sea cages. Tensioned cages can also be used to prevent access by predators in the water which attack the sides or base of the cage. However, these cages must be adequately tensioned and of a suitable mesh size to reduce the risk of predators becoming entangled. It is unacceptable deliberately to set nets so that predators are trapped and die. Predator damage can be prevented or reduced by scarers or shooting.

224. Many of the animals which prey upon farmed fish are themselves protected by law. All wild birds are protected by the Wildlife and Countryside Act 1981. Otters are protected by both the 1981 Act and the Conservation (Natural Habitats &c) Regulations 1994. Mink, whilst not specifically protected, may not be killed by certain methods laid out in the 1981 Act and the 1994 Regulations. Seals are protected during the closed (breeding) season by the Conservation of Seals Act 1970, and by the 1981 Act and the 1994 Regulations with regard to killing at all other times.

225. The killing of predators should be an absolute last resort and must be done within the constraints of the legislation protecting that species. Removal of individual animals will normally merely lead to re-occupation of the area by others, the major cause of predator presence being access to an abundant food supply. The primary objective of any action against predators should be physical exclusion or scaring.

Recommendations: salmon and trout

226. Adequate measures to reduce predation should be incorporated into all farms at the design stage.

227. Research should be undertaken to improve systems of predator control through investigation of modes of predator attack in relation to cage design and fish behaviour; improved design of cages, predator nets, deployment of nets (including use of weights, mesh sizes etc.) and resolution of problems associated with predator nets e.g. water flow reduction, increased drag, net fouling, and the entangling of predators.

228. Where measures are taken to protect fish from predators this should always be done in a way which minimises poor welfare of the predators and does not endanger predator populations. The killing of predators should be a last resort.

229. Salmon producers should follow the Salmon Farming and Predatory Wildlife Code of Practice which is produced by the Scottish Salmon Growers Association.

GENETICS

SALMON AND TROUT

230. In comparison with other farm animals, salmon and trout have been kept for farming for a short time and little modification has been achieved by genetic selection. Farmed carp may differ from natural stocks in minor body-shape changes but the major changes in body-shape have been achieved by selection in largely ornamental species, particularly goldfish *Carassius auratus.*

231. Genetic engineering by chromosome manipulation to produce all-female broods and triploid individuals is widely practised in trout farming. These have no obvious welfare implications. Future genetic engineering by gene transfer may have welfare implications.

Recommendation: salmon and trout

232. No use of genetic engineering outside the control of the Animals (Scientific Procedures) Act 1986, except for currently used procedures for triploid fish production, should be permitted unless the absence of effects of the procedure on the welfare of the fish has been demonstrated by properly conducted scientific studies.

KILLING AND SLAUGHTER

- SALMON
- TROUT

SALMON AND TROUT

233. Farmed fish must be killed humanely, indeed the same principles of humane slaughter should apply to the killing of farmed fish as those which apply to the killing of farmed birds and mammals. The Welfare of Animals (Slaughter or Killing) Regulations 1995 apply to all farmed animals including farmed fish. However, only the general provisions of the Regulations apply to fish. Those provisions make it an offence for any person engaged in the movement, restraint, stunning (see glossary for definition), slaughter or killing of fish to cause any, or permit any, fish to sustain any "avoidable excitement, pain or suffering". We believe this law should be interpreted as including avoidable fear and distress where it refers to "avoidable excitement, pain or suffering". The provisions also require that such persons have the knowledge and skill necessary to perform those tasks humanely and efficiently. Those parts of the 1995 Regulations which make specific provision with regard to the stunning of animals do not apply to fish. We consider 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.

234. Prior to slaughter, fish are often deprived of food for some days. This is acceptable only in order to improve conditions for the fish during the stressful period of crowding and transport prior to slaughter (see also the section on feeding). Care should also be taken to minimise stress from handling operations prior to slaughter.

Recommendations: salmon and trout

235. If a fish is to be stunned, the stun must cause immediate loss of consciousness which lasts until death.

236. A fish must not be stunned unless it can be bled or otherwise killed without delay.

237. If a fish cannot be stunned, any killing method must result in rapid and irreversible loss of consciousness.

238. Transfer from the pen or tank to the killing facility should cause a minimum of avoidable excitement, pain or suffering to the fish.

SALMON

239. Killing methods currently in use are: exsanguination without prior stunning, manual percussive stunning, with or without subsequent bleeding, and carbon dioxide narcosis followed by exsanguination. The chosen method of killing is at present dictated by a variety of factors including the volume of fish being handled and different demands on fish farmers by their customers. This latter factor may include details of how fish should be handled and slaughtered and whether or not they should be bled. However, there is an increasing awareness in the industry of the need to ensure that slaughter takes place under humane conditions and that fish should be stunned prior to slaughter by a method which causes immediate loss of consciousness which lasts until death.

Exsanguination alone

240. This is done by tearing or cutting one or both gill arches and leaving the fish to bleed to death. The method results in convulsive movements and muscular spasms which continue for a considerable time. While convulsions at the later stages may occur after brain death through loss of blood, it is reasonable to assume that early convulsive movements are a reaction resulting from pain or distress caused by the method itself and conscious attempts by the fish to escape the environment of the bleed-out tank. This does not fulfil the criteria set out above, including the basic legislative requirement, and the practice should be forbidden.

Percussive stunning or killing

241. Percussive stunning by a blow to the back of the head with a small club called a priest (followed by exsanguination if desired) is highly effective in producing insensibility when properly applied. However, the strength of the blow must be sufficient for the fish not to recover (a percussive kill) or must be immediately followed by exsanguination to ensure that the fish do not recover consciousness before death. The efficiency of the percussive stun or kill could be reduced if large numbers of fish were being handled and it is therefore important that those undertaking the operation are adequately trained in its technique and are rested before they become tired and inefficient. Inefficiency also leads to excessive bruising. Larger fish are more difficult to handle and particular care should be taken when they are to be stunned or killed by manual percussion.

Narcosis followed by exsanguination

242. This method involves putting the fish in water which has been pre-treated with a gas, normally gaseous carbon dioxide, until movement ceases and then severing the gill arches. Carbon dioxide exposure must be followed by exsanguination or percussive killing if recovery is to be prevented. Care must be taken that all fish in the batch have progressed from immobility into insensibility before bleeding takes place. After severing the gill arches fish are placed in seawater to bleed out.

243. Some concern has been expressed in relation to the aversive behaviour observed in fish when exposed to carbon dioxide treated water. However, it has also been demonstrated that it is possible to expose salmon to carbon dioxide in sea water without producing an unacceptable response. It is essential that carbon dioxide concentrations are maintained at the correct levels, which can be identified by measuring pH. The fish must remain in the carbon dioxide treated water for sufficient time to become insensible. We understand that research is underway using inert gas mixtures which may be less aversive to the fish and look forward to seeing published results.

Recommendations: salmon

244. Staff employed in the killing of fish must have the knowledge and skill to perform the task humanely and efficiently regardless of the method employed as required by the Welfare of Animals (Slaughter or Killing) Regulations 1995.

245. Fish must be stunned or killed before their blood vessels (gill arches) are severed for bleeding and when stunned remain insensible until death supervenes.

246. When the percussive method is used, the blow must be of sufficient force for the fish to be immediately rendered unconscious and for it to remain so until dead.

247. Those undertaking slaughter, e.g. by percussive stun or kill, must not continue if they become tired and inefficient.

248. Particular care should be taken when large fish are slaughtered using percussive stun or kill.

249. Further research is needed on the method of stunning and killing salmon, especially to find a satisfactory method of mechanical stunning or killing and alternatives to carbon dioxide as an anaesthetising or killing agent.

TROUT

250. The basic methods of killing in trout farming are by suffocation, by a blow to the back of the head, or by electric stunning followed by evisceration. The last two methods are only used on small scale retail outlets and most of the larger farms simply drain water away from the fish leaving them to die of anoxia or carbon dioxide poisoning. There is an increasing awareness in the industry of the need to develop humane methods of killing trout. Some farmers have tried other methods such as supercooling and carbon dioxide stunning but these are only effective if followed by immediate evisceration. Trout taken out of water and cooled on ice take much longer to die but remain sensible to stimuli (Kestin, Wotton and Gregory, 1991) and we recommend that this method should be prohibited.

Electrical stunning or killing

251. Where electrical methods are used, trout are usually stunned and eviscerated immediately afterwards. This is acceptable as long as the process of evisceration includes removal of the heart.

The strength and duration of the current used is important if fish are not to recover consciousness before evisceration. Fish could also be killed by electric current. Various methods are used to stun trout electrically. In the UK electrical stunning is limited at present to small scale operations although it is used on a commercial scale in Denmark and elsewhere.

Percussive killing

252. Percussive killing using a priest (a small club) is highly effective, when properly carried out, in bringing about insensibility until death supervenes. However, the strength of the blow must be sufficient to ensure the fish does not recover. The efficiency of the percussive kill could be reduced if large numbers of fish were being killed and it is therefore important that those undertaking any such operation are adequately trained in its technique and are rested before they become tired and inefficient.

Narcosis

253. There is potential for the killing of trout by use of inert gases in water. At present this is not used as a method of killing but should be investigated as an alternative for the future.

Recommendations: trout

254. Trout must be killed in a humane way and 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.

255. A satisfactory method of slaughtering trout en masse which renders them insensible instantaneously until death supervenes is urgently required. There should be research to develop acceptable methods of humanely killing trout, for example electrical methods. The method should be used in water or immediately after the fish are removed from water.

256. Staff employed in slaughter of fish must have the knowledge and skill to perform the task humanely and efficiently regardless of the method employed as required by the Welfare of Animals (Slaughter and Killing) Regulations 1995.

257. When the percussive method is used the blow must be of sufficient force for the fish to be immediately rendered unconscious and for it to remain so until dead.

258. The cooling of live trout on ice after they have been removed from water should be prohibited.

SUMMARY OF RECOMMENDATIONS

SALMON

1. An adequate water supply of suitable quality for the fish must be available in salmon hatcheries and in tanks for older fish (Paragraph 26).

2. Systems for providing an adequate supply of good quality water in hatcheries and for growing fish in tanks, must have alarms to indicate malfunction, must be inspected regularly and should be monitored carefully (Paragraph 27).

3. Hatcheries, equipment and tanks should be properly cleaned between batches (Paragraph 28).

4. Sites for sea cages and the design of the cage must be chosen so as to avoid unacceptable conditions for the fish in good or bad weather (Paragraph 29).

5. Outdoor tanks and sea cages should have adequate means for protection of the fish from predators (Paragraph 30).

6. The requirements of salmon for environmental stimulation should be investigated (Paragraph 31).

7. Netting used in the construction of sea cages should present a smooth surface to limit injuries to the fish. Studies should be carried out to find out how to minimise injuries to the snout and fins of salmon in cages (Paragraph 32).

8. An adequate method for the daily removal of dead and moribund fish from tanks and sea cages must be available (Paragraph 33).

9. Automatic feeding systems must be properly maintained and should be inspected every day where weather permits (Paragraph 34).

10. Feeding of fish should be such that the quality, quantity and frequency are optimal for their stage of development. The early feeding of fry and young fish should be monitored (Paragraph 80).

11. Food should be distributed evenly and widely so that it reaches the maximum number of fish. Better systems for the provision of adequate amounts of food to all fish should be developed (Paragraph 81).

12. Fish should not be totally deprived of food except during a period of up to 72 hours before slaughter for food hygiene reasons, or where the overall effect of food deprivation is an improvement in fish welfare (Paragraph 82).

13. The period during which fish may be deprived of food prior to certain management procedures must be kept to a minimum and should normally not exceed 72 hours (Paragraph 83).

14. There should be scientific research carried out on the interrelationships between food distribution, fish size and fish welfare (Paragraph 84).

15. During the stripping and milking processes the number of times a fish is handled and exposed to sedation should be minimised to avoid undue skin injury and stress (Paragraph 102).:

16. If live fish are stripped an effective anaesthetic must be used, and must be maintained at the correct concentration throughout the procedure (Paragraph 103).

17. Where compressed air is used to assist stripping in live fish they must be fully anaesthetised (Paragraph 104).

18. *The stripping and milking processes should be carried out by fully trained and competent personnel (Paragraph 105).*

19. Eggs should be inspected soon after fertilisation and frequently thereafter for signs of fungal infestation (Paragraph 111).

20. Fry should be inspected regularly, preferably daily, for signs of disease and parasites. Where these are detected there should be rapid investigations and suitable treatment should be instigated promptly (Paragraph 112).

21. High standards of hygiene must be observed within hatcheries to prevent the transmission of disease (Paragraph 113).

22. There must be an adequate supply of water of a quality that is suitable for the fish (Paragraph 114).

23. The stocking densities in hatcheries should allow for adequate oxygen provision for each fish (Paragraph 115).

24. The stocking density must allow fish to show most normal behaviour with minimal pain, stress and fear. Pending scientific research on the welfare of salmon in sea cages, 15 kg/m³ should be considered as an acceptable stocking rate. Higher densities may also be acceptable for short periods prior to slaughter and during treatment for disease and parasites (Paragraph 121).

25. Research should be undertaken urgently to determine acceptable maximum stocking densities taking account of factors referred to in paragraph 120 and including objective measures of the welfare of the fish. These results should be available within five years, at which point we expect to recommend the introduction of legislation to limit stocking densities (Paragraph 122).

26. Efforts should be made to reduce mortality between the parr stage and slaughter by improving existing management systems and developing systems which are better for fish welfare (Paragraph 123).

27. Aquaculture systems should be designed such that disease is minimised (Paragraph 182).

28. Fish in holding units should be inspected daily by experienced personnel for signs of disease in the stock and any necessary action must be taken immediately (Paragraph 183).

29. The industry should endeavour to develop better methods of inspecting fish to recognise those which are diseased, distressed or dead (Paragraph 184).

30. During an outbreak of disease where the cause of death is not immediately apparent, laboratory examination should be carried out to enable treatment to the remaining fish to be initiated (Paragraph 185).

31. Health certified or vaccinated stock should be used wherever possible (Paragraph 186).

32. Farmers should practice routine disinfection of equipment and clothing of personnel to reduce the risk of transfer of disease (Paragraph 187).

33. Leaving sites fallow will reduce the risk of disease or parasite transmission. Management agreements with other operators to fallow wider areas before restocking will reduce this risk level as will information exchange about disease (Paragraph 188).

34. Stocking density must be kept within manageable levels for the holding facilities (Paragraph 189).

35. Handling must be minimised so as to lessen susceptibility to disease (Paragraph 190).

36. Holding units should be cleaned and disinfected once all fish are removed (Paragraph 191).

37. Different year classes should be kept on separate sites to avoid cross infection (Paragraph 192).

38. National disease control should be maintained and outbreaks of any serious diseases should be reported to the national authority (Paragraph 193).

39. Staff employed in the killing of fish must have the knowledge and skill to perform the task humanely and efficiently regardless of the method employed as required by the Welfare of Animals (Slaughter or Killing) Regulations 1995 (Paragraph 244).

40. Fish must be stunned or killed before their blood vessels (gill arches) are severed for bleeding and when stunned remain insensible until death supervenes (Paragraph 245).

41. When the percussive method is used, the blow must be of sufficient force for the fish to be immediately rendered unconscious and for it to remain so until dead (Paragraph 246).

42. Those undertaking slaughter, e.g. by percussive stun or kill, must not continue if they become tired and inefficient (Paragraph 247).

43. Particular care should be taken when large fish are slaughtered using percussive stun or kill (Paragraph 248).

44. Further research is needed on the method of stunning and killing salmon, especially to find a satisfactory method of mechanical stunning or killing and alternatives to carbon dioxide as an anaesthetising or killing agent (Paragraph 249).

TROUT

45. When siting a trout farm the producer must take all reasonable steps to ensure that an adequate water supply of suitable quality will be available for all fish at all times (Paragraph 43).

46. Water supplies for trout hatcheries, whether ground water or not, must be suitable for the fish in terms of the temperature, dissolved gas content, pH, chemical quality, sediment levels and levels of pathogens and parasites (Paragraph 44).

47. The design of farm facilities should take account of welfare issues and, in particular, ensure that injury is not caused to the fish (Paragraph 45).

48. Outdoor holding facilities should adequately protect the fish from predators (Paragraph 46).

49. The requirements of trout for environmental stimulation should be investigated (Paragraph 47).

50. Automatic equipment such as water pumps and aeration systems must be monitored and incorporate alarms to indicate malfunction. Automatic feeding systems must be properly maintained and should be inspected daily (Paragraph 48).

51. Hatcheries, equipment and tanks, and further growth facilities should be properly cleaned and disinfected between batches of eggs or fish. Earth ponds should be emptied of fish and water and left fallow at suitable intervals (Paragraph 49).

52. An adequate method for daily removal of dead and moribund fish from tanks, ponds and raceways must be available (Paragraph 50).

53. Fish should only be kept in the outflow channel if the quality of the water there is high (Paragraph 51).

54. Feeding of fish should be such that the quality, quantity and frequency is optimum for their stage of development. It is important to monitor the early feeding of fry and young fish (Paragraph 91).

55. Food should be distributed evenly and widely so that it reaches the maximum number of fish. Better systems for the provision of adequate amounts of food to all fish should be developed (Paragraph 92).

56. Depriving trout of food prior to certain management procedures should be to achieve gut evacuation and not to adjust body composition, and the period should normally not exceed 48 hours (Paragraph 93).

57. Trout should not be totally deprived of food except during a period of up to 48 hours before slaughter for food hygiene reasons, or where the overall effect of food deprivation is an improvement in fish welfare (Paragraph 94).

58. There should be scientific research carried out on the interrelationships between food distribution, fish size and fish welfare (Paragraph 95).

59. During the stripping and milking processes the number of times a fish is handled and exposed to sedation should be minimised to avoid undue skin injury and stress; effective anaesthetics must be used and these must be maintained at an effective concentration throughout sedation and anaesthesia (Paragraph 127).

60. Where compressed air is used to assist stripping, the fish must be fully anaesthetised, or dead (Paragraph 128).

61. The stripping and milking processes should be carried out by fully trained and competent personnel (Paragraph 129).

62. Male trout must be humanely killed before removal of their testes (Paragraph 130).

63. The use of hormones in sex inversion must be carefully controlled, under veterinary supervision, and should be carried out by fully trained and competent personnel (Paragraph 132).

64. Shock treatment of eggs, which is used in the production of triploid fish, should be employed only by fully trained and competent personnel (Paragraph 134).

65. Eggs should be inspected soon after fertilisation and frequently thereafter for signs of fungal infestation (Paragraph 137).

66. Fry should be inspected regularly, preferably daily, for signs of disease and parasites. Where these are detected there should be rapid investigations and suitable treatment should be instigated promptly (Paragraph 138).

67. High standards of hygiene must be observed within hatcheries to prevent the transmission of disease (Paragraph 139).

68. There must be an adequate supply of water of a quality that is suitable for the eggs and fry (Paragraph 140).

69. The stocking densities in hatcheries should allow for adequate oxygen provision for each fish (Paragraph 141).

70. The stocking density must allow fish to show most normal behaviour with minimal pain, stress and fear. Scientific research is needed on the effect of stocking density on fish welfare but it seems that 30-40 kg/m^3 is too high a stocking rate for trout. Higher densities may be acceptable for short periods prior to slaughter and during treatment for disease and parasites (Paragraph 144).

71. Research should be undertaken urgently to determine acceptable maximum stocking densities taking account of factors referred to in paragraph 143 of the report and including objective measures of the welfare of the fish. These results should be available within five years, at which point we expect to recommend the introduction of legislation to limit stocking densities (Paragraph 145).

72. Efforts should be made to monitor trout mortality accurately and to develop management methods and stocking densities which reduce it (Paragraph 146).

73. Aquaculture systems should be designed such that disease is minimised (Paragraph 197).

74. Fish in holding units should be inspected daily by experienced personnel for signs of disease in the stock and any necessary action must be taken immediately (Paragraph 198).

75. The industry should develop better methods of inspecting fish to recognise those which are diseased, distressed or dead (Paragraph 199).

76. During an outbreak of disease where the cause of death is not immediately apparent, laboratory examination should be carried out to enable treatment of the remaining fish to be initiated (Paragraph 200).

77. Health certified or vaccinated stock should be used wherever possible (Paragraph 201).

78. Farmers should carry out routine disinfection of equipment and clothing of personnel to reduce the risk of transfer of disease (Paragraph 202).

79. Fallowing sites will reduce the risk of disease and parasite transmission (Paragraph 203).

80. Stocking density should be kept within manageable levels for the holding facilities (Paragraph 204).

81. Handling should be minimised so as to lessen susceptibility to disease (Paragraph 205).

82. Holding units should be cleaned and disinfected once all fish are removed (Paragraph 206).

83. National disease controls should be maintained and outbreaks of any serious disease should be reported to the national authority (Paragraph 207).

84. Trout must be killed in a humane way and 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 (Paragraph 254).

85. A satisfactory method of slaughtering trout en masse which renders them insensible instantaneously until death supervenes is urgently required. There should be research to develop acceptable methods of humanely killing trout, for example electrical methods. The method should be used in water or immediately after the fish are removed from water (Paragraph 255).

86. Staff employed in slaughter of fish must have the knowledge and skill to perform the task humanely and efficiently regardless of the method employed as required by the Welfare of Animals (Slaughter and Killing) Regulations 1995 (Paragraph 256).

87. When the percussive method is used the blow must be of sufficient force for the fish to be immediately rendered unconscious and for it to remain so until dead (Paragraph 257).

88. The cooling of live trout on ice after they have been removed from water should be prohibited (Paragraph 258).

SALMON AND TROUT

89. Fish farms should be managed by an adequate number of suitably trained and competent persons (Paragraph 58).

90. Aquaculture training at colleges etc. should include the welfare of farmed fish (Paragraph 59).

91. The industry should pursue training schemes which are validated (Paragraph 60).

92. Whenever possible, fish should be conditioned to the proximity of farm staff so as to reduce fear responses (Paragraph 61).

93. Where handling is necessary for the purposes of inspection, this must be kept to a minimum (Paragraph 62).

94. Where welfare problems are discovered remedial action must be taken promptly and, if necessary, with the assistance of a veterinarian or other expert (Paragraph 63).

95. Dead and moribund fish must be removed daily except when this might involve danger to personnel who work on sea cages (Paragraph 64).

96. Water quality should be assessed frequently both visually and by the use of monitoring equipment which must be fitted with alarms to alert staff to unacceptable conditions. Staff should be available to respond to alarms which indicate a potential risk to the fish and should take appropriate action if emergencies arise (Paragraph 65).

97. Fish farmers must record live fish movements onto or off the site, fish mortalities and medicines used (Paragraph 66).

98. In the interest of good management, producers should record details of feeding, numbers and weight of fish, stocking density, growth and water quality measures, as unexpected changes may indicate a welfare problem (Paragraph 67).

99. Records should also be kept of any maintenance carried out and of generator and alarm tests (Paragraph 68).

100. Handling equipment and procedures should be designed to minimise stress in the fish (Paragraph 150).

101. Handling equipment should be properly maintained (Paragraph 151).

102. Fish should be handled by trained and competent personnel only (Paragraph 152).

103. Grading equipment and procedures should be designed to minimise stress and injury (Paragraph 156).

104. Automatic grading equipment must be regularly maintained and an alarm fitted to alert staff in the event of breakdown (Paragraph 157).

105. Fish populations should not be graded more often than is absolutely necessary since most kinds of grading are likely to be stressful for fish (Paragraph 158).

106. The welfare of fish in transit by road should be checked at intervals not exceeding four and a half hours, the duration before which a commercial driver is obliged to take a break under road traffic legislation (Paragraph 164).

107. Fish in transit should be in conditions which will allow them to survive a journey at least 50 per cent longer than the anticipated duration (Paragraph 165).

108. Both the salmon and trout industries should give consideration to the need for Codes of Practice on transport which refer directly to fish welfare (Paragraph 166).

109. Crowding before collection for transport or killing should not be so prolonged or severe that unnecessary suffering is caused (Paragraph 167).

110. Oxygen levels must be constantly monitored and drivers should have the facility to adjust levels from the cab. Carbon dioxide should not be allowed to rise to levels which harm the fish (Paragraph 168).

111. Excessive changes in water temperature and pH in transport tanks must be avoided (Paragraph 169).

112. Transport containers should be cleaned and disinfected after conveyance of each consignment of fish (Paragraph 170).

113. Fish must be checked before transport and unfit or unhealthy fish must not be transported (Paragraph 171).

114. We endorse the requirement of the Welfare of Animals during Transport Order 1994 (as amended) that a written record must accompany fish during transport (Paragraph 172).

115. Nets used for catching and handling fish must not injure the skin or fins of the fish, for example they should be knotless (Paragraph 173).

116. It is essential that the welfare of farmed fish is not adversely affected by limiting the availability of vaccines or therapeutic medicines which are known to be effective and do not pose a food safety or environmental hazard. Ways must therefore be found to achieve rapid availability of vaccines and medicines to deal with emergencies such as major outbreaks of disease, and also to increase the range of vaccines and medicines approved for the treatment of fish. Well-tried and efficient medicines must not be lost unless adequate alternatives are available (Paragraph 218).

117. In principle FAWC is opposed to the unnecessary mutilation of farmed animals solely as an aid to management. Mutilations which involve removal of sensitive tissue should not be carried out on farmed fish (Paragraph 220).

118. Marking methods should be used only where they cause minimal damage to the fish (Paragraph 221).

119. Adequate measures to reduce predation should be incorporated into all farms at the design stage (Paragraph 226).

120. Research should be undertaken to improve systems of predator control through investigation of modes of predator attack in relation to cage design and fish behaviour; improved design of cages, *predator nets, deployment of nets (including use of weights, mesh sizes etc.) and resolution of problems associated with predator nets e.g. water flow reduction, increased drag, net fouling, and the entangling of predators (Paragraph 227).*

121. Where measures are taken to protect fish from predators this should always be done in a way which minimises poor welfare of the predators and does not endanger predator populations. The killing of predators should be a last resort (Paragraph 228).

122. Salmon producers should follow the Salmon Farming and Predatory Wildlife Code of Practice which is produced by the Scottish Salmon Growers Association (Paragraph 229).

123. No use of genetic engineering outside the control of the Animals (Scientific Procedures) Act 1986, except for currently used procedures for triploid fish production, should be permitted unless the absence of effects of the procedure on the welfare of the fish has been demonstrated by properly conducted scientific studies (Paragraph 232).

124. If a fish is to be stunned, the stun must cause immediate loss of consciousness which lasts until death (Paragraph 235).

125. A fish must not be stunned unless it can be bled or otherwise killed without delay (Paragraph 236).

126. If a fish cannot be stunned, any killing method must result in rapid and irreversible loss of consciousness (Paragraph 237).

127. Transfer from the pen or tank to the killing facility should cause a minimum of avoidable excitement, pain or suffering to the fish (Paragraph 238).

WRASSE

128. Wrasse should be able to obtain refuge from predation by birds and attack by large salmon (Paragraph 210).

129. Wrasse should be removed from sea cages before or during the grading of salmon (Paragraph 211).

130. Wrasse should be removed from cages when food is withdrawn from salmon (Paragraph 212).

131. Food must be provided for wrasse if sufficient is not available (Paragraph 213). **:**

APPENDIX A: THE FARM ANIMAL WELFARE COUNCIL

Background

The Council is an independent advisory body on farm animal welfare which was established by the Government in 1979. Its terms of reference are, "to keep under review the welfare of farm animals on agricultural land, at market, in transit and at the place of slaughter, and to advise the Minister of Agriculture, Fisheries and Food and the Secretaries of State for Scotland and Wales of any legislative or other changes that may be necessary". The Council can investigate any topic falling within its remit and communicate freely with outside bodies, the European Commission and the public.

Membership

Professor Sir Colin R W Spedding CBE- Chairman
Dr M Baxter
Mr G Berry
Dr W J M Black MBE
Professor D M Broom
Mr J Dewhirst
Mr T Harris
Mrs F F Hodgson
Mr C Hollands OBE
Mr A R Lucas
Mrs J MacArthur Clark
Miss C A Milburn
Mr R Macpherson
Dr M Pattison
Mr F E Shields MBE
Mr P F Staines MBE
Mr J G Thomas
Mrs J Turnbull
Mr A Watkins
Dr A Winter

Mr B Atkinson, Revd. A L Birbeck and Mrs T Wickham stood down from Council in 1995.

Method of investigation

A working group of members carried out an extensive consultation exercise, obtained oral and written evidence from experts in salmon and trout production and carefully examined scientific data. Visits were made to a number of fish farms in the UK and Norway; a seminar was held with invited experts from industry and research bodies; and evidence was taken from animal protection societies.

Those who gave evidence and information are listed at Appendix B and we would like to extend our thanks to them all.

The working group was aided by expert advice from Dr C Purdom, formerly from MAFF's Fisheries Laboratory, Lowestoft and Professor A Hawkins, SOAEFD Fisheries Laboratory, Aberdeen and the Council is indebted to both for their ready and valuable assistance.

APPENDIX B: THOSE WHO GAVE EVIDENCE AND ASSISTANCE

Animal Concern (Scotland)
British Trout Association
Compassion in World Farming
Convention of Scottish Local Authorities
Queens University of Belfast
Fish Veterinary Society
Humane Slaughter Association
Institute of Fresh Water Ecology
Ministry of Agriculture, Fisheries and Food
Royal Society for the Prevention of Cruelty to Animals
Scottish Natural Heritage
Scottish Office Agriculture, Environment and Fisheries Department
Scottish River Purification Boards Association
Scottish Salmon Board
Scottish Salmon Growers Association
Scottish Society for the Prevention of Cruelty to Animals
Shetland Salmon Farmers' Association
Shropshire County Council, Department of Trading Standards - National Animal Health and Welfare Panel
Stirling University
The Royal Norwegian Ministry of Agriculture
Torry Research Station
University of Bristol
Veterinary Medicines Directorate

VISITS

Anna Valley Trout Farm (Hatchery)
Aqua Farm Ltd
Ardvar Salmon
Exmoor Trout Farm
Kimbridge Trout
Landcatch Ltd
Landlocked Salmon (Europe) Ltd
Lovat Fisheries
MAFF Fish Disease Laboratory, Weymouth
Munton and Fison Plc
North Atlantic Fisheries College
Padworth Fisheries
Saga Seafoods Ltd
Test Valley Trout
Upwey Trout Farm

APPENDIX C: GLOSSARY

alevin:	yolk-sac fry of the salmon family
anadromous:	migrating up-river to breed
brood stock:	fish set aside for breeding purposes
dead sock:	narrow, sock-shaped, lower extension of the net of a fish cage
degree-day:	temperature in degrees C x duration in days
exsanguination:	bleeding so that a large proportion of the blood volume is lost
eyed-embryo:	an embryo that has reached the stage where the eye is pigmented
fallowing:	a resting period, for ponds or cages, without fish
fingerling:	fish of about finger length, i.e. 10cm ± 5cm
fish pump:	a pump in which the impeller is designed to move fish and water without harm to the fish
flexibacterium:	a class of bacterium characterised by a non rigid appearance microscopically
fry:	that stage of fish development between alevin and fingerling
grilse:	a salmon that becomes sexually mature after one summer at sea
MAFF:	Ministry of Agriculture, Fisheries and Food
milking:	the stripping of milt from male fish
milt:	semen of male fish
motility:	the ability of, for example, spermatozoa to swim by lashing the tail
parr:	fingerling salmon distinguished by a series of darker patches, parr marks, on the flanks
photoperiod:	the period, or periods, of light during 24 hours
phototactic:	moving towards light
priest:	a small club
raceway:	long tanks, usually of concrete, through which water flows at a steady rate
ROV:	remotely operated vehicle
sea cage:	a fish cage robust enough to be used in the sea
smolt:	the final freshwater phase of the young salmon, silver in appearance and able to enter sea water
SOAEFD:	Scottish Office Agriculture, Environment and Fisheries Department
sporozoan:	a single-celled microscopic animal that reproduces by spore formation
stripping:	the removal of eggs and milt from fish by massage
stunning:	a process which causes immediate loss of consciousness in an animal
triploid:	an animal with three sets of chromosomes instead of the usual two sets
water hardening:	in the presence of water fertilised eggs stabilise and become turgid
well-boat:	a boat with part of the hold perforated to allow water to flow in or out

APPENDIX D: FISH DISEASES AND PARASITES

DISEASE	PATHOGEN	SALMON	TROUT
Bacterial			
Bacterial kidney disease (BKD)	*Renibacterium salmoninarum*		
Enteric redmouth (ERM)	*Yersinia ruckeri*		
Furunculosis	*Aeromonas salmonicida*		
Septicaemia	*Aeromonas hydrophila*		
Rainbow trout fry syndrome (RTFS)	*Cytophaga pyschrophila*		
Cold water disease	*Cytophaga pyschrophila*		
Edwardsiellosis 2	*Edwardsiella tarda*		
"gill fever" (gill irritation)	*mixed non specific*		
Vibriosis	*Vibrio anguillarum,* *Vibrio ordali*		
Hitra disease	*Vibrio salmonicida*		
Septicaemia 2	*Streptococcus*		
Protozoan			
Proliferative kidney disease (PKD)	*PKX*		
Ich, white spot	*Ichthyophthirius*		
Viral			
Infectious haematopoietic necrosis (IHN)2			
Infectious pancreatic disease (IPN)			
Infectious salmon anaemia (ISA) [1]			
Viral haemorrhagic septicaemia (VHS)			
Pancreas disease			
Fungal			
Saprolegniasis	*Saprolegnia parasitica*	(freshwater)	

Helminths			
Gyrodactyliosis	*Gyrodactylus salaris* [2]		
Other helminths	*Dactylogyrus spp*		
Sporozoans			
whirling disease			
Crustaceans			
Sea lice	*Lepeopthririus*		
Fish louse	*Argulus spp*		

1 exotic to the European Union

2 never found in Great Britain

APPENDIX E: REFERENCES

Busch, L. 1992. *New Scientist* 133, 1808, p.26.

Echteler, S.M. and Saidel, W.M. 1981. *Science*, 212, 683-685.

Ehrensing, R.H., Michell, G.F. and Kastin, A..J. 1982. *Pharmacology Biochemistry and Behaviour,* 17, 757-761.

Flos, R., Lourdes, R., Torres, P. and Tort, L. 1988. *Aquaculture,* 71, 99-106.

Ingle, D. 1968. In: *The central nervous system and fish behaviour.* Ed. Ingle, D. University of Chicago Press. Chicago.

Laming, P.R. 1981 (Ed.) *Brain Mechanisms of Behaviour in Lower Vertebrates.* Cambridge: Cambridge University Press.

Mathews, G. and Wicklegren, W.O. 1978. *Journal of Comparative Physiology.* 123, 329-333.

Pickering, A.D. 1981. In: *Stress and Fish* (A.D. Pickering, ed.). Academic Press.

Pickering, A.D. 1989a. *Freshwater Biology*, 21, 47-55.

Pickering, A.D. 1989b. *Report of the Freshwater Biology Association, UK.* 57, 61-80.

Strange, R.J. and Shreck, C.B. 1978. *Journal of the Fisheries Research Board of Canada*, 35, 345-349.

Sumpter, J.P., Dye, H.M. and Benfey, T.J. 1986. *General and Comparative Endocrinology,* 62, 377-385.

Verheijen, F.J. and Buwalda, R.J.A. 1988. *Report of the Department of Comparative Physiology.* Utrecht: CIP Gegevens.