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Articles, letters and news relating to trout farming or the production of coarse and coldwater ornamental fish are always welcome and may be included in future issues.

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TROUT PRODUCTION

2002 SURVEY OF TROUT PRODUCTION IN SCOTLAND

Data supplied from SERAD (Rural Affairs Department of the Scottish Executive) Annual Production Survey, 2002 via the website: www.marlab.ac.uk

Rainbow trout were produced from 45 sites involving 39 companies with an overall production of 6,659 tonnes in 2002 (5,466 tonnes in 2001) an increase of 1,193 tonnes on the previous year (almost 22%). Trends in production over the last 10 years are given in Table 1 below.

Table Production

Table 2 gives trends in production for table fish over the past 8 years. Production in 2002 amounted to 5,711 tonnes representing an increase of 1,037 tonnes (23%) on the previous year and accounting for 86% of total production. Fish weighing up to 450 g made up the bulk of production representing 51% of table production.

Restocking Production

Table 3 provides production data for the restocking trade for the last 8 years. Production for restocking increased by 156 tonnes (almost 20%) to 948 tonnes representing 14.2% of the total production (14.5% in 2001).

Escapes

There were three escape events in 2002, which involved the loss of a total of 82,400 fish.

Table 1. Total production for the period 1993-2002

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Tonnes	4,023	4,263	4,683	4,630	4,653	4,913	5,834	5,154	5,466	6,659

Table 2. Production of table fish for the period 1995-2002

Year	<450g <1lb	450 - 900g 1-2 lb	>900g >2lb	Total Tonnes
1995	2,736	199	1,149	4,084
1996	2,701	181	1,002	3,884
1997	2,646	104	1,098	3,848
1998	3,009	173	887	4,069
1999	3,151	144	1,562	4,857
2000	3,005	203	1,103	4,311
2001	3,053	404	1,217	4,674
2002	2,937	1,056	1,718	5,711

Table 3. Production of restocking fish for the period 1995 - 2002

Year	<450g <1lb	450 - 900g 1-2 lb	>900g >2lb	Total Tonnes
1995	107	411	81	599
1996	188	484	74	746
1997	97	589	119	805
1998	69	538	237	844
1999	236	552	187	975
2000	41	609	193	843
2001	18	526	248	792
2002	28	484	436	948

Method of production

Table 4 provides a breakdown of trout farms by system and scale of production. Freshwater production accounted for 5,662 tonnes (85% of the total) while seawater production increased by 78% on the previous year to 997 tonnes (15% of the total).

Production and manpower by region

The regional production and manpower information shown in Table 5 relate to Scottish Local Government Regions following their reorganization in 1996. Productivity ranged from 29.4 to 68.1 tonnes/person between regions, being greatest in the West and least in the South. Mean productivity in tonnes/person for the four regions reached 41.6 tonnes in 2002 representing an increase of 7.2 tonnes on the previous year. Over the same period staff employed increased by 1 to 160.

Other species

Other species farmed in Scotland together with the production figures for the last two years are given in Table 6.

Ova production in Scotland

The number of rainbow trout eyed ova laid down for hatching from Scottish produced stock, from other sources within Great Britain and from foreign imports are given in Table 7 for the period 1994 – 2002. The proportion of ova laid down from GB broodstock decreased to 730,000 representing 3.3% of the total. The total number of eyed-ova laid down decreased by almost one million (3.9%) on the 2001 figure.

Table 4. Analysis of rainbow trout farms by system and scale of production

Production method	Production grouping (tonnes) in 2002					Total tonnage and (%) by method		Number of Sites	
	<10	10-25	26-50	51-100	>100	2001	2002	2001	2002
FW Cages	0	1	1	0	7	2,639 (48.3)	3,462 (52)	10	9
FW Ponds and Raceways	4	8	4	8	6	2,146 (39.2)	2,194 (32.9)	25	30
FW Tanks and Hatcheries	3	0	0	0	0	120 (2.2)	6 (0.1)	7	3
SW cages	0	0	0	0	3	561 (10.3)	997 (15)	3	3
SW tanks	0	0	0	0	0	0	0	0	0
Total	7	9	5	8	16	5,466	6,659	45	45

Table 5. Rainbow trout production and staffing by area in 2002

Area	No. of Sites	Production			Mean tonnes/ Sites	Staffing			Productivity tonnes/ Person
		Table	Restocking	Total		F/T	P/T	Total	
North	7	473	106	579	82.7	14	4	18	32.2
East	19	1,472	375	1,847	97.2	39	17	56	33
West	13	2,892	104	2,996	230.5	32	12	44	68.1
South	18	874	363	1,237	68.7	29	13	42	29.4
All	57	5,711	948	6,659	116.8	114	46	160	41.6

Table 6. Production of other species in tonnes for 2001 and 2002

Species	Production	
	2001	2002
Atlantic Salmon	138,519	145,609
Arctic Char	3.75	7.2
Brown trout/Sea trout	105	175.7
Cod	15	0
Halibut	80	187.2

Type of ova

Details of the number and type of ova laid down for hatching in Scotland are given in Table 8. The preference for all female diploid stock was again evident, accounting for 89% of all ova laid down. Triploid ova decreased to 8% of the total, while mixed sex ova showed an increase from 140,000 to 570,000, or 3% of the total.

Imported rainbow trout eggs in 2002

The number and source of imported rainbow trout ova for the period 1996 – 2002 are given in Table 9. The total imported in 2002 – 21,225,000 represents a decrease of 365,000 (1.7%) on the previous year.

Table 7. Number (000s) and sources of ova laid down for hatching in 1994-2002

Year	Scottish Stock	Other GB Stock	Total GB	Total 3rd Country	Grand Total	% GB
1994	479	625	1,104	18,500	19,604	5.6
1995	165	360	525	20,310	20,835	2.5
1996	420	988	1,408	21,270	22,678	6.2
1997	1,232	837	2,069	21,434	23,503	8.8
1998	2,559	60	2,619	22,633	25,252	10.4
1999	878	392	1,270	17,361	18,631	6.8
2000	1,397	900	2,297	18,686	20,983	10.9
2001	918	525	1,443	21,590	23,033	6.3
2002	530	200	730	21,395	22,125	3.3

Table 8. Number (000s) and proportions (%) of ova types laid down for hatching in 1994-2002

Year	All Female Diploid Nos. (%)	Triploid Nos. (%)	Mixed Sex diploid Nos. (%)	Total Ova
1994	18,105 (92)	1,134 (6)	365 (2)	19,604
1995	19,546 (94)	1,170 (6)	119 (<1)	20,835
1996	21,308 (94)	935 (4)	435 (2)	22,678
1997	21,118 (90)	1,386 (6)	1,000 (4)	23,503
1998	23,222 (92)	1,515 (6)	504 (2)	25,241
1999	16,324 (88)	1,853 (10)	456 (2)	18,633
2000	17,264 (82)	1,202 (6)	2,513 (12)	20,979
2001	20,788 (90)	2,107 (9)	140 (1)	23,035
2002	19,733 (89)	1,822 (8)	570 (3)	22,125

Table 9. Number (000s) and sources of ova imported into Scotland during 1995-2002

Source	1995	1996	1997	1998	1999	2000	2001	2002
Northern Ireland	6,285	4,095	2,425	2,065	3,335	1,085	710	-
Isle of Man	3,550	4,182	4,205	3,273	4,222	5,842	6,670	6,775
Denmark	2,650	5,075	5,354	5,700	4,546	4,225	6,135	5,000
Other EU	-	220	-	-	-	-	-	-
South Africa	7,825	8,023	9,450	11,585	6,036	7,762	8,075	7,750
USA	-	-	-	-	-	-	-	1,700
Totals	20,310	21,595	21,434	22,623	18,139	18,914	21,590	21,225

EUROPEAN TROUT PRODUCTION

The latest production figures for rainbow trout released by the Federation of European Aquaculture Producers (FEAP) on its website (http://www.feap.org) are given in Table 1 below for 22 European countries. The figures for large rainbow trout are for fish in excess of 1 kilo in weight and include both fresh-water and sea-grown production. Total European production for 2002 is estimated to be nearly 370,000 tonnes with Norway again as the leading producer at 83,000 tonnes, followed by France and Italy with 42,900 and 42,500 tonnes respectively. UK production estimated at 17,400 tonnes ranked eighth in the league of European trout producing countries.

Table 1. European production of portion-sized (P) and large (L) rainbow trout for the period 1997-2002

Country	1997	1998	1999	2000	2001	2002
Austria	3,000 P	3,000 P	3,000 P	3,000 P	3,000 P	3,000 P
	400 L	400 L	400 L	400 L	400 L	400 L
Belgium/ Luxembourg	700 P	700 P	700 P	600 P	600 P	400 P
	120 L	100 L	100 L	100 L	100 L	
Cyprus	105 P	90 P	66 P	90 P	90 P	90 P
Czech Republic	499 P	554 P	723 P	700 P	700 P	656 P
Denmark	29,300 P	32,000 P	30,000 P	30,000 P	30,000 P	31,000 P
	7,000 L	7,500 L	7,500 L	7,500 L	7,000 L	6,500 L
Faroe Islands	100 L	1,000 L	2,169 L	1,141 L	4,000 L	10,000 L
Finland	16,500 L	16,500 L	15,300 L	15,200 L	15,200 L	14,500 L
France	42,000 P	42,500 P	37,000 P	37,500 P	37,500 P	32,500 P
	8,000 L	8,000 L	8,000 L	10,000 L	10,000 L	10,400 L
Germany	23,500 P	23,500 P	22,500 P	22,500 P	22,500 P	23,000 P
	1,500 L	1,500 L	2,500 L	2,500 L	2,500 L	2,500 L
Greece	2,322 P	2,334 P	2,800 P	2,500 P	3,000 P	3,000 P
Hungary				27 P	30 P	29 P
Iceland	580 L	300 L	100 L	180 L	500 L	500 L
Ireland	1,000 P	1,000 P	1,000 P	1,000 P	1,000 P	1,000 P
	300 L	300 L	1,100 L	1,400 L	1,600 L	700 L
Italy	50,000 P	47,000 P	43,200 P	43,700 P	43,000 P	41,900 P
	1,000 L	1,000 L	800 L	800 L	1,000 L	600 L
Netherlands	200 P	200 P	10 P	10 P	10 P	200 P
Norway	34,000 L	47,000 L	50,000 L	47,000 L	60,000 L	83,000 L
Poland	6,500 P	9,000 P	9,000 P	10,160 P	11,000 P	11,000 P
Portugal	1,500 P	1,500 P	1,500 P	1,500 P	1,500 P	1,500 P
Spain	25,000 P	26,000 P	27,000 P	28,500 P	29,500 P	29,500 P
	850 L	700 L	700 L	1,500 L	1,500 L	4,500 L
Sweden	200 P	200 P				
	4,875 L	6,500 L	7,250 L	7,000 L	7,000 L	3,500 L
Turkey	18,075 P	20,125 P	17,200 P	18,220 P	18,220 P	35,250 P
	2,000 L	2,500 L	2,200 L	2,400 L	2,400 L	1,240 L
UK	11,800 P	12,640 P	13,200 P	15,200 P	16,500 P	16,200 P
	800 L	950 L	600 L	2,600 L	2,600 L	1,200 L
Totals - Portion Size	215,701	222,343	208,889	215,207	218,150	230,225
Totals - Large Size	78,025	94,250	98,719	99,721	115,800	139,540
Grand Total	293,726	316,593	307,608	314,928	333,950	369,765

ARTICLES

BRITISH TROUT FARMING CONFERENCE, SPARSHOLT 4-5 SEPTEMBER, 2003

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A total of 13 papers were presented over the two days of this conference covering a wide range of industry related issues. The first day covered a diverse array of topics from sustainability, through farm technology and genetics to marketing. The second day focussed on feeding, welfare and disease, thereby providing a well balanced overall programme with subjects of interest to all sections of the audience. The following report, complied by Field Inspectors from CEFAS Weymouth covers the papers delivered on the first day of the conference.

Sustainability of Aquaculture

The first paper by John Hambrey from Hambrey Consulting, discussed "Fisheries, aquaculture & sustainability". Sustainability has become an extremely important consideration and environmental pressure groups frequently question the sustainability of aquaculture. Aquaculture has been seen as unsustainable, irreversible and irresponsible and far from being the solution to diminishing wild stocks, aquaculture has been vilified as a contributing factor through the growing demand for fishmeal and fish oil. Given the increasing discrimination of the general public and the immense power of the media, it was suggested that the challenges presented to the industry can no longer be ignored.

John initially addressed the meaning of sustainability and suggested that a better range of sustainability criteria could be developed with regards to aquaculture. The issue of who should make the assessments of sustainability, planning and management to promote sustainable aquaculture and the need for a proactive response from the industry were all points raised during the presentation. John indicated that the existing regulatory and management tools are inadequate to address the scope of sustainability, and whilst the Water Framework Directive and the Integrated Coastal Management initiatives, may well provide a more appropriate management framework, it will be some time before these are effective. In the meantime it is up to the aquaculture industry to demonstrate to the general public and the media that it understands the key issues and sustainability as a whole.

There are no absolute sustainability criteria – the industry needs to demonstrate *relatively* good performance according to a reasonable range of social and environmental criteria. Because of the varied range of institutions developing sets of criteria (OECD, EC, EEA World Bank, etc), there is an opportunity for the industry to select (in line with existing assessment frameworks) a reasonable set of indicators and publish them in the form of an industry sustainability profile and performance report. The BTA was highlighted as a suitable body to take a lead in this issue where time is of the essence. If the industry does not take the initiative now, they could be forced to conform to criteria that are unfair to the industry as a whole.

Significant steps have been made in recent years in improving the production efficiency, quality control and environmental status. However, if the undoubted potential of aquaculture as a sustainable food production industry of the future is to be realised, reliable sustainability criteria must be met.

Efficiency in trout farming

Anders Andreassen, a technical advisor for BioMar, gave a presentation on improving the efficiency of trout farms through farm design. The two main areas of improvement covered in the talk were optimising the farm layout and improving the water quality to allow the most efficient feeding strategy. Using these two approaches the overall aim is to maximise both the environmental conditions and the feed utilisation.

The talk was illustrated with three case studies of traditional farms that had been re-engineered to increase productivity. The first of these was Adler Fish Farm in Russia, which was an extensive, earth pond system with an annual production of 500 tonnes from 106 ponds. The challenge was to increase the production whilst being able to cope with high summer temperatures and a limited water supply. The most significant problem was the low rate of water exchange, taking 9 hours to pass through the farm, leading in the summer to a 10°C difference between inlet and outlet water temperatures, low oxygen levels and the suspension of feeding.
The redesigned site was a concrete raceway system

occupying 10% of the original site with 4-5 times the quantity of aerated water per tonne of fish and a 2-hour water exchange. The increased stocking density, water flow rate and adequate oxygenation was made possible by the use of airlift pumps and the introduction of faeces collectors at the end of each raceway, the raceways being connected in a maze type arrangement.

The second farm was Gryde Å Fish Farm, a concrete raceway farm in Denmark with problems of reduced water flow and massive fluctuations in oxygen levels in incoming water at the inlet, and at the outlet following feeding. Again the improvements were based on solids removal using sludge traps and aeration using airlift pumps. Following these changes the oxygen fluctuations were reduced, and this stabilised oxygen content allowed a twofold increase in the feeding levels from 220 kg per day to 420 kg per day. The holding capacity of the site following the improvements was 140 tonnes at 9°C, and 80 tonnes at 15°C.

The final case study was Farre Fish Farm in Denmark, which was looking to increase production whilst reducing the reliance on potentially contaminated river water in a VHS affected catchment area. The engineered solution to this was to design a recirculation unit using a biological filter bed with submerged solids removal system to reduce the ammonia loading, which was the limiting factor in production. During periods of low water temperature the farm can provide sufficient oxygen by using air-lift pumps. However, in order to operate the system when the water temperature is above 16°C, it is necessary to use liquid oxygen at 0.24 kg per kg food fed. The system is more energy intensive than conventional gravity-fed designs, but the design allows the farm to be isolated from the potentially infected source of river water.

One of the issues raised at the end of the talk was the difficulty of treating these serial flow units and the potential for disease transmission to adjacent stocks. The speaker's response was to say that the systems as described could all be isolated from the inlet water source and have the water plus any treatment recirculated through the farm using the airlift pumps which are integral to the designs.

Biofilters

Bent Højgaard, an aquaculture consultant specialising in the planning, design and construction of fish farms, followed up his 2002 talk on recirculation by focussing on biofiltration. He illustrated the design and principles behind biofiltration with a case study providing a virtual tour (aided by a sophisticated PowerPoint presentation) of a salmon smolt unit in Chile. He indicated that a well-functioning recirculation farm will have low running costs, be of good construction and have well-trained staff.

There are three stages involved in water filtration on fish farms: mechanical, biological and bacterial filtration. These processes are particularly important on farms using re-circulation with the aim of removing particulates (mainly uneaten food and faeces) and dissolved material (ammonia and other excretory products).

The first stage in the filtration process is to remove particles by mechanical filtration, which can be performed by drum, screen or conveyor filters. The collected particulates are then washed off the filter. This by-product can be used for combined fertilisation/irrigation in agriculture. In the Chilean case-study, this waste water is transferred to a lagoon for settling, and then irrigates a commercial forestry enterprise, thereby preventing discharge back to the river course and protecting the environment.

Ammonia is the main dissolved nitrogenous waste and can rapidly build up to toxic levels. It is removed by bacterial filtration in which *Nitrobacter* and *Nitrosomonas* bacteria convert the ammonia to nitrite and nitrite to nitrate respectively. There are various designs of filters providing a medium on which the bacteria can grow including fixed and moving (fluidised) bed filters. As this is an aerobic process requiring oxygen, a good example of this type of system is the fixed bed trickling filter in which the water is open to the air as it trickles down. Although far less toxic than ammonia, nitrate does need to be removed in recirculation systems when there is little water replacement. Nitrate is removed by conversion to gaseous nitrogen in an anaerobic process in submerged filters.

Bacterial numbers can build up in the water being recirculated through a system, and are typically reduced by sterilising with UV. At ambient temperatures of 14°C, for example, the UV process is not efficient. The UV tubes are therefore placed in core sleeves to maintain high operating temperatures of around 40°C.

Selective Breeding

Brendan McAndrew from the Institute of Aquaculture and John Woolliams from the Roslin Institute gave a talk on the progress made in selective breeding in the UK rainbow trout industry. Brendan spoke first, providing the background to the LINK funded project which has been running for two years. The project aims to look at the status of rainbow trout stock in the UK and to try to obtain selective improvement using mass selection and genetic markers. The project represents a collaboration between the Institute of Aquaculture, Stirling, the Roslin Institute, the British Trout Association and four UK trout farms (Glen Wyllin, Trafalgar, Houghton Springs and Test Valley Trout).

The project began by identifying and prioritising the desired characteristics - disease resistance, growth rate, less size variation etc.- of a selective breeding programme. This was done via a questionnaire sent to BTA members, which was supplemented by visits to hatcheries, fingerling sites and processing plants. The rationale behind the practical part of the project is that stocks differing in traits are already available within the UK due to genetic isolation, rather than any deliberate scientific intervention. The recent introduction of new tools - PIT-tagging and genetic finger printing - would be used to identify individuals and the parentage of progeny held in mixed stocks. The genetic finger-printing used a genotype gel to identify published micro-satellite loci.

Breeding trials have begun at the above fish farms, and they have been elaborate in order to maximise the genetic information. To ensure results are applicable, grow-out has been under normal commercial conditions. To ensure scientifically rigorous results, all families are spawned on the same day, with each parent being used in several crosses. Growth performance and PKD resistance is being monitored during grow-out. At present, all the parents have been genotyped, the pit tagging has been completed and the PKD samples have been collected. Additionally research is being carried out by CEFAS into VHS disease resistance.

John Williams then took over to discuss the theoretical background to a selective breeding programme and the potential outcomes of the project. He illustrated that selective breeding is an advantageous method for improving performance because it is permanent, cumulative (over generations), straightforward to implement, widely accepted and has a high benefit to cost ratio. This LINK project provides a rich design and will enable multiple parameters to be estimated, i.e. strain differences, the extent of hybrid vigour, the robustness of traits in differing grow-out environments, the heritabilities of a range of traits. He concluded that this is an exiting project with a wide ranging remit. It has potential to increase profits for all concerned and the industry as a whole.

Genetic Selection

Jim Parsons from Troutlodge, Washington gave a presentation on the current status of genetic improvement in aquaculture from an industry perspective. The speaker started with a brief introduction about Troutlodge describing their involvement with genetic improvement of trout stocks since the late 1970s. In line with the industry slant to the talk, the first point made was that genetically improved (GI) strains make economic sense, as improvements to stock mean increases in profit. The current status and the public perception of GI trout were discussed together with the need for farmers to be more aware of the benefits of choosing stock from GI broodstock. The wide applications of genetics in the world today were mentioned with examples of genetic research advances made in food products and in the field of medicine as well as the well documented controversies about 'genetically-engineered' foods.

The basis of improved fish performance was given as being an interaction between genes and environment and a definition was given as: Performance =G+E+G×E, where G = genes and E = environment. The importance of the genetic influence was illustrated by the use of 'BLUP' (Best Linear Unbiased Predictors) in animal breeding over the last 30 years. BLUP was first used as a predictor of random effects in the dairy industry and its subsequent use contributed to an increase in annual milk yields per cow from 2 tonnes to 4.7 tonnes over a 25 year period. The poultry industry was given as another example of genetic improvement via well-defined genetic improvement programmes. Over a 40 year period there has been a 30% increase in egg production, and the time to market for a broiler chicken has reduced from 26 to 7 weeks.

The speaker then posed the question whether the aquaculture industry was as advanced in terms of GI, and if not what were the reasons for this. The trout industry has made some advances such as the introduction and acceptance of mono-sex production and polyploidy (triploidy). However there is still more that can be done and there is a need to overcome the scepticism of the industry about the cost effectiveness of new developments. This was illustrated with two slides on the different views held by farmers, who are profit oriented, and scientific researchers whose last concern has been the potential profits made by growers. The point behind this being that commercial research and development companies (such as Troutlodge) are best positioned to produce focused research on genetic improvement.

This was a cue for a description of the work being undertaken at Troutlodge on developing strains of trout with improved performance in terms of growth and disease resistance. The programme of family selection at the Troutlodge facility allows individually 'PIT' tagged fish to be followed throughout their entire growth cycle, allowing comparisons between strains to be made. When compared to control groups, the progeny from broodstock that were selected from the upper quartile of the highest market weight fish had a roughly 10% higher market weight. This work is ongoing and the best performers are continually being selected from each year-class. Similarly, although the mechanisms of resistance are not well known, work on producing disease resistant fish has shown that fish from selected IPN resistant strains appear to transfer immunity to subsequent generations.

The conclusion of the presentation was that the industry can do better, and that when compared to advances made in other fields, aquaculture is lagging behind in genetic improvement. The way to progress is to keep growers informed of changes, and the benefits of improved strains and to expand R&D trials carried out at Troutlodge to a 'real world' scale.

Trout markets

Mr Andrew Cookson (GIRA) opened his talk entitled "Trout Markets: can stagnation be turned into profitable growth?" by outlining the current situation in the UK trout industry as one of stagnant consumption with a very fragmented production base. The industry also appears to have very little or no resources for market development. He then went on to highlight rainbow trout production figures (including imports and exports) for Spain, France, Denmark, Italy, Germany and the UK. There was very little difference between the major players of Spain, France, Italy and Denmark with the UK being the smallest and Germany falling in between. The only significant exporter is Denmark which sends most of its production to Germany. It was highlighted that all the other countries live in splendid isolation but the question asked was for how long?

An analysis of the changes in the UK market for table trout products between 2001 and that predicted for 2006 showed that the market was uncomfortably stable with total consumption only likely to rise by 0.9% for the period. The main conclusion for the industry being that the situation only remained tenable as long as there are no significant imports. Attention was drawn to the only sector having significant predicted growth, i.e. other processed foods at +9.5% (non-smoked products).

Several key points were then made with regard to the product's image. Trout should be marketed as very digestible and containing a specific 'vitamin', i.e. Omega 3. He suggested that the public perception is more in tune with vitamins than fatty acids. There is a general feeling that it would be great to encourage children to eat more fish, but whole fish products suffer as they are often put off by the bones. Fish is valorised in the UK compared to meat by the absence of blood. He went on to point out that the UK consumer has no problem with the farming process if the appropriate message is communicated. For trout this means highlighting a special area for egg laying and hatching, a separate area for rearing with plenty of room, a flowing current to develop firm flesh and an omnivorous diet, rather than being solely carnivorous. There does not appear to be a mental block for UK consumers at the thought of a vegetarian diet for fish. Other benefits of fish farming which could be highlighted to improve the image of trout are the strict health controls, the fact that the water is filtered and constantly changed, the efficient logistics (fish are iced and transported quickly) and the standardisation and availability brought about by farming. Another idea put forward was that the industry should envisage the creation of new varieties like the fruit market. Consumers are already aware that there are different species of trout.

Andrew suggested that unfortunately the current image of trout is of an 'old' product and a 'frumpy aunt' of salmon, with far less perceived convenience and health aspects. As consumption is stagnant or falling, there is a need for new product development in the area of convenience foods accompanied by product differentiation e.g. by region, species etc. He suggested that as the UK trout market is self sufficient, more effort should be put into valorising domestic origin of trout as there is for meat.

Trout producers are under heavy economic pressure as the price is strongly influenced by the salmon price but the economies of scale available to salmon producers are not available to trout producers. This may be made even more difficult if cheap salmon imports increase. Trout therefore has to be 'uncoupled' from salmon - and this means real marketing. A very fragmented production base means that there is currently no leader to develop new products or drive marketing and consumer communication. Merger or acquisition among the top four companies could give rise to a group with the volume, resources and know-how to develop the market.

The talk was concluded by stating that the problem is not the product, it is the producers, and that the opportunity is there but who is going to take it? Trout poses the classical problem of an old product that has become a commodity in the eyes of consumers and retailers. Only product differentiation can solve the problem and add perceived value. It is certainly not trace-ability and sustainability that will sell more products to customers. It will be an uphill task, necessitating industry consolidation and a major mind change – from a 'producer push' to a 'consumer pull' mentality. But the alternative is continuing stagnation, followed by steady decline and further devalorisation of the product.

TROUT SLAUGHTER - TIME FOR A CHANGE

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This article is based upon a talk given at the 2003 Sparsholt BTF Conference

Background

The widely used practice of slaughtering trout in ice slurry was strongly criticised by the Farm Animal Welfare Council[1] in their 1996 report on the welfare of farmed fish. Recognising the damage to the industry that could result from adverse publicity, the British Trout Association joined forces with trout retailers, Defra, and the Humane Slaughter Association to fund an investigation into an alternative slaughter method suitable for freshwater trout farms. This resulted in the development of an electric stunning system, the first commercial version of which was installed in December 2003. The main supermarkets are following these developments and assessing how they will respond.

A slaughter system is humane if the animal is not exposed to pain or suffering. This can be achieved by making the animal instantly insensible to pain, or by ensuring that the process of becoming insensible is not aversive to the animal. Once the animal is insensible, the actual cause of death is immaterial so long as it does not recover sensibility. No currently available trout slaughter equipment meets this welfare requirement and also meets the industry requirement for high carcass quality and high operational speed. Carbon dioxide systems, ice slurry and asphyxiation in air result in extended periods of distress before death. Mechanical percussion systems are unable to achieve the operational speeds required. Commercially available high voltage electric stunning systems cause increased carcass haemorrhages, while low voltage electric systems appear not to stun the fish but rather to electro-stimulate them to death. Anaesthetic systems such as AQUI-S ™ are not permitted in the UK. Following an examination of the available options we concluded that electric stunning could be developed to meet all the requirements. We therefore investigated this approach and identified techniques which achieve humane slaughter at a suitable speed without causing carcass damage.

Humane slaughter using electric stunning

In the slaughter system developed, the trout are stunned by placing them in water across which an electric field (voltage) is applied. If the electric field is of a suitable strength, then the trout become insensible instantly. However they are capable of recovering from this stun if the electric field is removed too soon. After a suitable exposure to the electric field (typically 30 or 60 seconds) the fish are so deeply stunned that they are all either dead or incapable of recovering sensibility. The fish can then be removed from the water and placed in ice slurry without compromising their welfare.

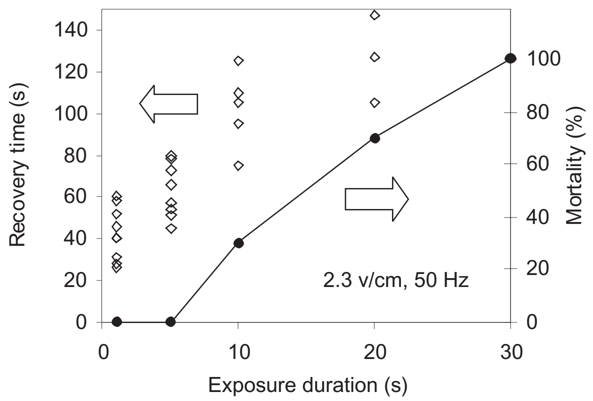

Figure 1. Result of exposing trout to a 50Hz electric field of 2.3 V/cm in water of conductivity 650 µS/cm. Open diamonds show individual recovery times, solid line shows percentage mortality of the group

We were able to determine the state of sensibility of the fish at each stage of the slaughter process by removing them from the stunning tank, placing them in fresh water and observing their behaviour. Earlier work (Kestin *et al*., 2002) identified some simple behaviours which indicated when sensibility returned to the fish. These include eye movement when the fish is rotated, a response to pressure at the tail, and the return of coordinated gill movement.

[1] *The Farm Animal Welfare Council (FAWC) is an independent advisory body established by government to advise DEFRA on animal welfare*

A high frequency (1000 Hz) sinusoidal voltage is used to stun the fish. Although this high frequency is more complex to generate than the standard 50 Hz (mains) frequency, it causes less muscular stress and so avoids the carcass haemorrhages that would otherwise occur. Carcass damage is also avoided by using relatively low electric field strengths. The actual electric field needed varies with the water conductivity. Experiments and mathematical modelling lead us to recommend the electric fields given in Table 1. These values still need to be treated with some caution however, since tests have not yet been performed under all possible conditions. Adjustments to these values may be needed if fish appear to be recovering.

Water conductivity varies widely across the UK, and is largely dependent on the geology of the river catchment area. In the course of this development some water conductivities have been measured, these include water on trout farms in the Cotswolds and south of England which had conductivities of 550 – 750 µS/cm, farms in North Yorkshire (150 – 350 µS/cm), and also in the Scottish borders (45 - 100 µS/cm). Water conductivity also has a significant effect on the electric power requirement. This can be calculated by the formula:

$$P = 0.001.\ E^2C$$

where P is the power in watts per litre of water, E is the electric field strength in V/cm (see Table 1), and C is the water conductivity in µS/cm.

The power requirement is significant not because of the cost of the electricity, but because of the capital cost of the electronics needed to generate the 1000 Hz electric field. This is likely to be a significant part of the overall capital cost of the equipment. Concern about this cost led to an investigation into power reduction techniques which resulted in the development of a two stage stun.

The two stage stun

The two stage stun is based on the observation that initiating a stun, and maintaining it until insensibility becomes permanent, are different processes with different requirements. The fish can be stunned by just a few seconds exposure to an electric field as given in Table 1. Once the fish are insensible, this state can be maintained by prolonged exposure to a lower strength electric field. Application of the lower strength electric field alone, however, would not stun the fish. This approach reduces the power demand by about 70%. A further advantage is that a 50Hz electric field can be used for the second, stun maintenance, stage without causing carcass haemorrhages. This reduces even further the requirement for high frequency electric power. The two stage approach has been tested in water with a conductivity of 600 µS/cm, and showed the same high standards of fish welfare and carcass quality as the single stage stun.

Methods of applying the stun

Three methods of applying this electric stun on the farm have been identified. The simplest method is a batch stunning tank where trout are introduced to a tank, exposed to the electric field, and removed into ice slurry after the required exposure. This is a relatively simple method, most suitable for harvesting at a small scale or a low rate. No significant advantages are likely to be gained from using a two stage stun with a batch stunning tank. In designing the tank it is important that the tank is rectangular with sheet electrodes covering the whole of two opposite sides of the tank, so that an even electric field is obtained.

For large harvests at high speed, a continuous operation is likely to be more suitable. This can be achieved by pumping fish through a long electrified stunning tube connected between the fish race and the dewatering unit. Fish pumped through this tube are exposed to an electric field in the tube for the required duration and emerge at the dewatering unit and harvest bins dead or permanently insensible. This approach is mechanically simple but has a relatively large electrical power requirement due to the large water volume in the tube. Use of a two stage stun significantly reduces the power requirement, making it feasible throughout the UK.

A third approach providing a more compact solution and a lower electrical power requirement uses a rotating cylinder of electrodes in a water tank. This has a lower electrical power requirement than the tube, since the water volume can be lower, however it is more mechanically complex. A two stage stun could be used advantageously in such a system, given an appropriate design.

Table 1. Minimum electric field strengths considered likely to result in a permanent stun when applied for 30 or 60s using a 1000Hz sinusoidal electric field

	Water conductivity					
	50 µS/cm	100 µS/cm	160 µS/cm	300 µS/cm	500 µS/cm	1000 µS/cm
60 second exposure	5 V/cm	4 V/cm	3 V/cm	2.5 V/cm	2.5 V/cm	2.5 V/cm
30 second exposure	6.3 V/cm	5 V/cm	4 V/cm	4 V/cm	3 V/cm	2.5 V/cm

Equipment following the third option was built, tested and demonstrated during the research project (Figure 2). We chose this option because it appeared to be the one which needed most development and because it suited our need for a transportable system which could be tested on a range of farms. A fuller description and evaluation of the machine is published elsewhere (Lines *et al.,* 2003).

This demonstration humane slaughter equipment has been used in small scale commercial harvests on a farm in Scotland and on two farms in England. It has also been loaned to Test Valley Trout, Trafalgar Trout and Scot Trout for further evaluation. Back to back comparisons with ice slurry slaughter show that haemorrhages are not increased. The electrically stunned trout lose fewer scales and produce less mucus, benefiting the visual appearance of the fish. The carcasses of the electrically stunned trout take longer to go into rigor, because they have not struggled during the slaughter process.

Commercial development

Two companies have declared an interest in supplying humane trout slaughter equipment.

A rotary device based loosely on the machine developed and tested during the project. is being developed by Test Valley Trout. Enquires should be made to:
Christopher Saunders-Davies, Test Valley Trout Ltd, The Island, Greatbridge, Romsey, SO51 0NU
Email: hq@testvalleytrout.co.uk
Tel 01794 512453

A flow-through, pipeline, stunner has been designed and built by Ace Aquatec. This unit automatically adjusts the electric field to suit the water conductivity, and uses a two stage stun to reduce power demand. The first commercial installation of this equipment was in December 2003 on a Scot Trout farm. Enquiries should be made to:

John Ace-Hopkins, Ace Aquatec, The Croft, 25 Castle Street, Dingwall, Ross-Shire, IV15 9HU
Email: john@aceaquatec.com
Tel 01349 863319

Interested parties should contact the manufacturers for prices and further details. A view of how well these machines achieve humane slaughter will be formed by the Humane Slaughter Association after the equipment has been tested. Purchasers are advised to discuss this aspect of the equipment with the HSA. Further general information may be obtained from the authors.

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References and further reading

FAWC (1996) *Report on the Welfare of Farmed Fish*. Farm Animal Welfare Council. http://www.fawc.org.uk/

Figure 2. Demonstration slaughter unit on test at Alderley Trout, Gloucestershire

Kestin, S.C., van de Vis, J.W. & Robb, D.H.F. (2002) Protocol for assessing brain function in fish and the effectiveness of methods used to stun and kill them. *Veterinary Record* 150, 302-308

Lines, J. A., Robb, D.H., Kestin, S.C., Crook, S.C. & Benson, T. (2003) Electric stunning: a humane slaughter method for trout. *Aquacultural Engineering* 28, 141-154

Robb, D.H.F. & Kestin, S.C. (2002) Methods used to kill fish: field observations and literature reviewed. *Animal Welfare* 11(3), 269-282

Robb, D.H.F., O'Callaghan, M.O., Lines, J.A. & Kestin, S.C. (2002). Electrical stunning of rainbow trout (*Oncorhynchus mykiss*):factors that affect stun duration. *Aquaculture* 205, 359-371

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RTFS: EXPERIENCES FROM DENMARK

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For the last six years, the Association of Danish Trout Farmers has been participating in a collaborative project with the Danish Institute of Fisheries Research, Fish Disease Laboratory, The Danish Veterinary and Food Administration Vejle, and Oxfeld Trout Farm. The project entitled 'Prevention of RTFS (Rainbow Trout Fry Syndrome) and the reduction in use of medication in Danish trout farms' has primarily resulted in new knowledge on the routes of infection of the RTFS bacteria and on methods to prevent infection.

Background

RTFS is caused by a Gram-negative rod bacterium called *Flavobacterium psychrophilum*. Disease transmission occurs through the water, with infected fish or asymptotic carriers shedding the bacteria into the water. The bacterium prefers cooler water and only causes disease at temperatures below 15°C. The clinical symptoms of the disease vary according to the size of the fish. In fry up to 10 g, the bacterium can cause a general septicaemia (blood poisoning). The fish become dark and lethargic, lack appetite, and have bulging eyes and very pale gills. Internally, the kidneys are grey, the liver is pale, the intestine is fragile, and the spleen is very swollen. In larger fish, the above symptoms can also develop, but the disease often manifests as ulcers without reddening of the skin, occurring on various parts of the body, but particularly around the dorsal fin. In larger trout, it is also known as cold water disease (CWD). The disease can cause high mortalities (80-90%), if an outbreak occurs at an early age and goes untreated. Different kinds of antibiotics have been used to treat RTFS over the years. Currently, the most effective drugs are florfenicol and amoxicillin-trihydrate and both need to be prescribed by a veterinarian. However, treatment of larger trout with CWD is rarely successful.

The disease was first diagnosed in Denmark at the beginning of the 1980s. Since then, it has spread throughout the whole trout industry in Denmark and very few trout farms are now free from RTFS. It has been estimated that RTFS causes an average mortality of 34% of initial fry numbers in hatcheries, corresponding to annual losses of 88 M fry, equating to 18 M DKR (equivalent to £1.7M). RTFS can also cause mortalities once the fry have been transferred from the hatchery to ongrowing ponds, as well as reducing growth by 30-40% in surviving fish.

Project results

The initial stages of the project demonstrated that RTFS was present on nearly all Danish broodstock farms. The disease appeared to be linked to poor gill condition, associated with poor water quality. The bacterium was also identified in egg and seminal fluid samples, indicating a clear potential for vertical transmission of bacteria from the broodstock to the eggs/fry.

The project then went on to examine whether transmission could be prevented by keeping the broodstock and fry in isolation units. A trial facility was built on Oxfeld trout farm in west Denmark. A borehole supply ensured pathogen-free water and water quality was maintained by using recirculation systems comprising an airlift, fixed biofilter and a fluidised biofilter. Before initial use and between batches of fry, the facility (including the biofilters) was cleaned and disinfected. The trial facility was divided into two completely separate units - one for broodstock and one for fry - each with an independent recirculation system. Each unit had its own entrance and biosecurity "air-lock" room comprising

- a basin for hand washing with disinfectant soap
- two coat racks – one near the entrance door for external 'infected' clothes, and one near the unit entrance for unit-specific boiler suits and boots.
- a watertight 10 cm elevation to prevent water entering the 'clean' unit
- wooden grating over half the floor area to differentiate 'infected' and 'clean' areas.

As far as possible, daily routine husbandry of the units was carried our before accessing the rest of the farm, typically by one person to minimise the number of visits.

Results from the Isolation Units

Despite being held in isolated conditions for over a year preventing re-infection from external sources, RTFS bacteria were still present in the broodstock fish and in their ovarian fluid. This demonstrates that broodstock fish cannot cleanse themselves of RTFS bacteria, and can be asymptotic carriers of RTFS. RTFS bacteria were indeed found associated with the eggs, demonstrating the potential for vertical transmission from broodstock to fry. However, the bacteria were only present on the outside of the eggs, so the risk of vertical transmission could theoretically be decreased by egg disinfection. Disinfection trials with 1% Actomar K30 demonstrated that the number of bacteria adhering to the egg surface could be reduced, although the bacteria were not eliminated completely.

Rearing trials demonstrated that by transferring disinfected eyed eggs to the isolation unit, the route of infection could be broken and fry were reared through the first critical months without experiencing an RTFS outbreak. In the latter stage of the project an initial 430 thousand eyed eggs produced 396 thousand 4 g fry (7% hatching mortality, 1% mortality from yolk-sac to transfer). In contrast, the vast majority of batches of fry reared on the farm outside the unit were diagnosed with RTFS. Due to the high infective pressure in the farm environment, fry reared within the isolation did frequently contract RTFS within 7-14 days of being transferred onto the farm. However, although they did contract the disease, they were of a size that made disease treatments much easier. Batches of fry reared initally in the isolation unit therefore experienced fewer losses than fry reared in the traditional hatchery.

Conclusions

The rearing of disinfected eggs to 4 g fry within the isolation unit proved successful in combating RTFS. However, to fully prevent RTFS, the fish would either have to be kept isolated for a longer period, or be vaccinated. Unfortunately, despite effort by several vaccine companies and universities, there is currently no RTFS vaccine available. Nevertheless, rearing in such an isolation unit would enable fry to be produced of a size that would be immunologically competent to respond to a vaccine.

It proved difficult to completely prevent pathogen entry into the isolation unit. Despite the biosecurity measures, various pathogenic micro-organisms were found in the isolation unit e.g. *Ichthyobodo* (formerly *Costia*), *Octomitus*, ERM bacteria, and in one season RTFS bacteria. The pathogens were presumably introduced on staff or husbandry/ grading equipment, due to the high infective pressure from the surrounding farm. It can therefore be suggested that such isolation units would be better placed remote to existing farms.

SLEEPING DISEASE: A LESSON IN BIOSECURITY

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This article is based upon a talk given at the 2003 Sparsholt BTF Conference

When I was volunteered to give a talk on sleeping disease to the British Trout Farming Conference at Sparsholt in 2003, my first reaction was that there was not a great deal of news to impart on this issue, despite the great drama it caused at the 2002 conference, soon after its first isolation in Britain. In sitting down and thinking further however it was clear that there were lessons that farmers, and the Fish Health Inspectorate, had learned, or could learn from the 2002 outbreak.

These lessons principally relate to the biosecurity of fish farming businesses, and therefore the theme of my presentation turned to biosecurity, with sleeping disease used an example to show why farmers should heed the lesson.

As background, sleeping disease, a viral infection affecting trout production to varying degrees in parts of continental Europe, made a first appearance in Britain at a trout farm in southern England in early summer 2002.

It was soon found to have arrived at three other trout farms in Scotland, and as a consequence the trade were desperate to learn more about the disease, how it could be controlled, what risks it posed to trout farmers, how it had arrived in Britain and what could farmers do to avoid the disease arriving on their farms.

One year later requests from industry for information on this disease have largely dried up, and the disease was barely mentioned by farmers during the Fish Health Inspectorate's fish farm inspection programme in 2003. So what does this show?

Principally it shows that the sleeping disease outbreak did not spread to other sites. In 2003 there was no recurrence of the disease on the English farm. Each of the 3 Scottish farms had seen the problem again in 2003, and had experienced losses of up to 30% of individual batches of fish, while water temperatures remained below 17°C. These farms however had adopted appropriate measures to prevent the transfer of the disease to other sites and were looking to manage the disease out of their existing stocks where possible.

The news was therefore as good as anyone could have hoped, and farmers appeared to have forgotten about their concerns of the previous year. The question is, have any lessons been learned, and are we any clearer about the risks from this and other diseases? I would contend that we are all poor at learning lessons and therefore have chosen to suggest a few areas where farmers could, in general, be more alert to the risks they face from disease introduction. So what lessons could be learned from the sleeping disease outbreak?

First, and possibly most important for farmers to understand, is that trout farming in Britain is not isolated from the risk of disease introduction, despite the fact that the industry is stable with most fish introduced to it coming from long established sources. Biosecurity therefore must be included in any farm business plan because, as sleeping disease showed, any introduction of disease will have an impact on farm trade, and reduced profits.

Second, investigations into the outbreak revealed a range of potential sources for the disease, none of which had been properly managed to prevent the introduction or spread of the disease. These included; the movement of live fish between farms; transport vehicles; movements of dead fish for processing onto a farm site, and the introduction of used undisinfected packing boxes onto a farm site. These potential avenues of disease introduction will be discussed below.

First however I will qualify what I wish to say with a few relevant points. First, any biosecurity measures are likely to require site specific solutions, so we can not provide catch-all solutions in this brief text. The measures discussed will necessarily be constrained by farm economics in some if not all cases. The suggestions put forward will almost certainly be implemented to a greater or lesser degree in many farms already, and all these suggestions are obvious if one applies a healthy dose of common sense.

So why am I going any further? Put simply, the major problem is not a lack of common sense or good practice or even a lack of money, it is in farmers taking the time to adapt their farm biosecurity measures to their changed farming practices, rather than sticking to their current and often long established routines, which may no longer be adequate. I therefore hope this presentation may open a few eyes.

Looking at the four possible causes of sleeping disease introduction and spread we can illustrate some of the various levels at which farm bio-security needs to be considered.

Introductions of live fish to a farm

Introductions of live fish pose the single biggest risk of disease introduction to any fish farm. An ideal form of biosecurity to eliminate such risk is therefore to be self sufficient and introduce no stock from any other farm. Clearly this is not a practical proposition for many farms, therefore other means to reduce the risk from such introductions need to be considered.

A trout industry in Britain is legally only able to import eggs from sources of known or acknowledged high health status. Farmer should not however assume that all farms of the necessary high health status are equally safe as a source of eggs. This can be illustrated with reference to imports from different types of farms.

Farms which export trout eggs to Brtain from outside the EU are subject to site specific disease testing at a high level (150 fish) twice per year, and are closed to introductions of stock. They therefore pose a very low risk of introducing any significant disease to British farms.

Imports of trout eggs from within the EU can come from a variety of sources. They can be from a farm situated in an approved zone for VHS and IHN, or from an approved farm for these diseases in a non-approved zone, or from a farm approved for one of these diseases situated in a zone approved for the other. While this may seem to be the creation of lots of words to describe equally 'healthy' sites, there are potentially significantly different risks involved in the movement of stock from these different categories of site.

For example for an approved zone to maintain its status, all farms must be subject to annual or twice yearly inspections and be sampled every second year. Where there is any suspicion or confirmation of VHS or IHN the zone will lose its status for that disease. While this broad programme of disease monitoring on farms should enable disease problems to be detected within a reasonable timescale, it does not mean that fish movements within or from such a zone do not pose a disease risk. For example there may be significant migrations of wild fish into a zone all of which may pose a risk of diseases introduction, which may not be detected for several months, given the monitoring requirements in place. While we can be reasonably confident that there is little risk of VHS or IHN arriving at a farm site supplying eggs from such a zone, this risk is not zero as some people seem to think.

An approved farm, ie one on an isolated water source, with a history of negative disease testing for VHS and IHN, would initially seem like a safe source for eggs equivalent to the third country farms. Such an approved farm however may be surrounded by farms in which there is an active outbreak of VHS or IHN, without losing its status. Clearly then there may be risks associated with movements of birds or other predators from nearby farms, from vehicles or persons entering the farm after visiting a nearby infected site and so on, in addition to the risks from any direct stock introductions to the farm. While the disease testing requirement on approved farms is higher than that for farms in approved zones, it is not equivalent to that applied to third country eggs sources, which have traditionally supplied eggs to Britain. Importers should consider carefully the real risks from any source they use, rather than assume that all legal sources of stock provide equivalent risk. They should certainly not assume zero risk from any source.

Britain historically only imports salmonids as eggs, which significantly reduces the risk of importing diseases such as VHS which are not vertically transmitted. Other approved zones may however allow introductions of live fish, which, if sourced in less biosecure approved farms, may increase significantly the risk of introduction of pathogens to that zone. The farm manager in Britain intending to import eggs from another farm in the EU should therefore consider carefully what the real risks are in choosing a particular supplier. How many British farmers have a detailed understanding of the risks that their EU suppliers are taking with their own stock? If you are importing eggs and are unaware of the exporters modus operandi then you are not taking your biosecurity as far as you could. This is not wise in the area (stock supply) posing the greatest risk of disease introduction.

Farmers should certainly place evidence of good biosecurity ahead of small differences in egg cost when choosing an egg supplier.

A conservative approach to stock introduction, which sees self sufficient British suppliers, or closed foreign farms subject to regular substantial disease testing, as the preferred options for egg supply will minimise the risk of disease introduction to individual farms and the industry as a whole.

Transport of fish

Next we consider the risk posed by the transport of stock. There is little point buying disease free stock if you transport it in a vehicle contaminated with a pathogen from its previous use. Again I state the obvious, but how many farmers can say they really manage the risk of disease introductions with transport equipment?

If you are to introduce stock to your farm, its transport by you, in your disinfected vehicle, or in your new or disinfected egg boxes is the simplest way to minimise the risk of infection of that stock.

Your supplier may of course wish to deliver the stock, after all why should he take the risk of having your vehicle on his farm? Such deliveries should be of low risk, particularly if that supplier is trading on the basis of having a disease free stock.

Many stock movements are now conducted by contractors, and it is at this point that farmers need to show increased diligence if they are not to run the risk of having diseases introduced to their farm. There are numerous points to raise with the contractor or supplier which could help to identify or reduce risk. For example does the supplier disinfect the transport vehicle at his site before loading stock? If not, does he have any evidence of earlier disinfection by the contractor.

When, where and for what was the transport vehicle last used? Is the consignment of fish for your farm a single load or is it part of a bus-stop type delivery of fish to a number of farms? If the latter, is your farm going to be the first destination? The answer to whether the transport vehicle poses the minimum risk of disease transfer lies with the working relationship and rapport you establish with your suppliers and transport contractors. They need to be fully aware of your needs and fully supportive of them. If they are not, then perhaps there are better places from which to obtain your stock, or better people to deliver it.

Even when you have arranged the best transport available, there are steps you can take to reduce further the risks to your farm when the new stock arrives. You should never assume that there is no disease risk.

Stock management

In an ideal world fish farmers would hold each batch of fish on independent water supplies, using equipment dedicated to each holding facility. The farm design would help prevent cross contamination of holding facilities during harvest or any other management operation, and all holding and other areas would be easily disinfected before stock introduction. In the real world however, most farms do not lend themselves to this situation, either due to design limitations, water supply limitations or the simple economics of fish production. This does not mean that good biosecurity is not possible on such farms. It means there has to be a greater emphasis on avoiding disease introduction, and on protecting the farm stock from disease for example by vaccination.

Since I joined the Fish Health Inspectorate in 1994 there appears to have been a significant improvement in stock management on trout farms in England and Wales. Inspectors see fewer cases of chronic disease problems, of overstocked farm ponds and of poor husbandry practices such as back-grading of stock. The number of disease outbreaks requiring testing on suspicion of notifiable disease has fallen markedly over this period.

It is therefore clear that farmers have in general devoted much of their effort towards improving husbandry on their farms. These efforts are commendable, and so I will not preach any further on this matter, but good husbandry, in isolation, is unlikely to give long term protection from disease problems, and farmers need also to consider the remaining risks posed by the other activities taking place on the farm.

Site management

We have discussed the risk of live fish movements to the farm, but what about the 'non-stock' risks. Any person or vehicle entering a fish farm will pose some risk of disease introduction. It is therefore important that farmers take steps to minimise such risks.

First they can restrict access to the farm to essential personnel only. Where visitors need access to the site they should, wherever possible, be kept away from production areas. Vehicles or any equipment arriving at the site should be disinfected on arrival and ideally on departure. Any visitors to the site should be provided with protective clothing rather than using their own, or be required to disinfect their own kit.

In addition to dealing with legitimate visitors, farmers must also account for the risks posed by unwanted visitors, namely predators. Again the degree to which predator control is needed may depend on several factors, such as their number and the number of adjacent farms posing a risk of cross contamination, and not just on the level of stock they steal or damage.

I will raise one final example of on-farm activity which poses a significant threat of disease introduction, namely the operation of a processing plant and in particular the introduction of stock for processing from other farm sites.

Processing plants

A number of salmonid farm businesses in Britain have developed processing facilities on or immediately adjacent to farm production units. Typically this has been done because the farmers only anticipated processing their own stock and because the economics of building and operating on such sites was favourable. The industry has however changed significantly in the last ten years and a number of such sites have increased their scope to process stock, with the consequence that the risk of disease introduction to the farm sites via the fish processing operation may have increased considerably.

The principal risk identified is that the fish entering processing plants may no longer come from sites of the same fish health status as the farm on which the plant is based. Fish from farms in continental Europe have been introduced to processing plants in Britain, to satisy demands from supermarkets for fish of a very exacting size range, when such fish are not readily available from local farms. While there are provisions intended to prevent the introduction of VHS and IHN by this trade route, there are no such constraints in respect of other diseases which may at present be exotic to Britain such as sleeping disease. I doubt that such disease risks have been fully accounted for by sites processing such fish, because the driver for such trade is the whole economics of their farming and fish processing business. Perhaps the assessment of disease risk should take a higher position in the business decision making process?

A second risk identified is the movement of equipment and packing materials to processing plants on farms. Many fish packaging materials are now subject to re-use, and as a consequence used and undisinfected boxes may be brought onto processing units. Where these units are sited on farms, the operators may need to look closely at the possible risk of pathogen introduction to the farm from such materials. Such materials should perhaps be disinfected prior to arrival on site. Their storage should certainly not be in areas where there is a risk of contamination of farm waters. Cleaning of such materials should pose no risk of waste water contact with the waters of the farm.

These two examples illustrate that fish processing may pose a risk of disease introduction to Britain that has increased in recent years almost unnoticed by farmers and, in truth, by some of us fish health professionals.

So how should processing plants be managed to reduce disease risks? First they should, if possible, be fully isolated from any farm production areas. Second, they should have water supply, water discharge and holding facilities that pose no risk of contamination of farm or natural waters. Third, waste storage, treatment and disposal should also be managed to cause no risk to the wider environment. Fourth, working practices at the plant should also prevent any equipment being moved onto a farm production area. Finally the operator of such a plant should be as aware as any farmer of the risks posed by introducing potentially infected fish, whether live or dead, to the site, and of the risks posed by transport vehicles, visitors etc.

In recognition of the risks from fish processing, there are proposals that the EU Fish Health regime should incorporate tighter controls on the operation of such plants, though at this stage there are few clear indications of what controls may be introduced.

I have highlighted a variety of area where farmers may need to consider the risk of disease introduction. Some farmers may still feel that they dealt with such matters many years ago and have everything under control. I will therefore close this article by illustrating that there are numerous changes proposed in the area of the Fish Health Inspectorate's responsibilities (my area of expertise), which may pose a real change in the risk of disease introduction to Britain in the coming years. Fish farmers need to understand some of these changes if they are to properly evaluate the future disease risks to their farms.

Legislative changes

First, there is a significant increase in trade in live fish around the world, principally as a result of the increase in number and types of fish in aquaculture. As a consequence there will be new and as yet unrecognised threats that novel pathogens will be introduced to regions with which we trade.

Second, one consequence of this increased trade in live fish is a need to adopt world fish health rules to accommodate these changes. Free trade principles and import controls for all diseases do not go hand in hand, and therefore there is pressure to reduce the numbers of serious diseases controlled by means of import restrictions, and a drive to have countries manage the disease risk once fish have been imported into their territory. These drivers may in some cases improve our disease controls, but in others may leave us vulnerable to the introduction of serious problems.

There are EU proposals to improve several aspects of disease control, including registration or licensing of traders/transporters of fish, increased controls on effluent treatment at processing plants and the import of live fish from third countries, for direct consumption, only to approved import centres.

There are however proposals which may undermine our current import controls. These include placing such controls only on species known to be susceptible to a particular disease. There is a further proposal to make disease testing risk-based rather than to a set of international standards, and to have official services in trading countries develop bi-lateral agreements on the import standards to be imposed for trade in particular species. While this will not necessarily reduce our ability to insist on a substantial disease testing history for farms exporting direct to Britain, it does mean that our existing trade partners in Europe may impose lesser import standards than ours, with the consequence that they become a potentially greater risk of disease transfer to Britain than they are at present.

As yet we do not know exactly how these proposals may effect the Fish Health Inspectorate's ability to control imports of fish into Britain, but we do know that fish farmers and the farm industry need to look closely at the risks their future trade may pose to their own and their industry's future.

Summary

Biosecurity should be a daily concern for fish farmers. The stability of the trout industry in Britain is no reason for it to be complacent about disease introductions. Sleeping disease was a clear warning to the industry of current risks. Changes in world trade and in fish health legislation globally may in future limit the ability of our official services to prevent disease introductions. Fish farmers and their trade organisations should therefore make significant efforts to ensure that they are aware of current and future risks and develop appropriate risk management strategies with other stakeholders.

Finally, in recognition that British farmers can and do apply good biosecurity measures in many instances, we compiled a handout (overleaf) of twenty tips for biosecurity on trout farms, with some photographic evidence to show that certain farmers do take these matters seriously. This is reproduced alongside this article. It is neither a definitive list or necessarily a list of the most important factors. It could however be a valuable guide to the areas of biosecurity a farmer needs to consider.

Twenty steps towards trout biosecurity

1. Stock only with certified, disease-free fish from a reputable supplier

2. Where possible use a pathogen free water supply (eg. spring, borehole) or uv/ozone treated water

3. Each fish holding facility should have an independent water supply ie. flow through from one tank or pond to another should be avoided

4. Staff should be trained in hygienic fish handling and in fish disease prevention methods

5. Production, processing and recreational (eg angling ponds) areas should be totally independent and separate from each other

6. Health and treatment records must be kept and be readily available to customers

Produced by Alasdair Scott FHI Weymouth
and Jim Gauld FRS Scotland

7. Morts and moribund fish should be removed daily and disposed of in accordance with EU legislation

8. All water, blood, packaging and organic waste originating at slaughter or processing sites should be contained and not allowed re-entry to production areas

9. Transfer of fish between farms should be done with caution (re stocking with eggs or fingerlings,etc)

10. Fish should not be subjected to undue stress arising from excessive stocking densities, poor water quality or poor husbandry

11. Regular veterinary checks should be undertaken and fish vaccination programmes and disease treatments introduced where appropriate

12. Pest management control must be applied to prevent disease spread by vermin or predators

13. Each unit on a farm should be isolated and have its own supply of equipment eg. nets, buckets etc.

14. If a farm consists of two or more distinct production areas (eg. hatchery and on-growing facilities), each area should have its own specific gear and disinfection facilities sited between the areas

15. Site specific protective clothing should be provided for visitors

16. To prevent the spread of disease within a farm hands, boots and equipment should be disinfected before moving between any fish holding facility on a farm (includes hand washes between tanks)

CEFAS – Fish Health Inspectorate, CEFAS Weymouth Laboratory, Barrack Road, The Nothe,

Weymouth, Dorset, DT4 8UB. TEL: 01305 206673/4
FAX : 01305 206602 www.efishbusiness.co.uk

17. Access to production areas should be limited eg. locate car parking at a distance from a production area; members of the public should not be allowed entry to production areas

18. Disinfection facilities (eg. sprays, footbaths) and clear notices requiring all visitors to disinfect boots and vehicles (wheels, wheel arches and under surfaces etc.) before entering and again on leaving a farm should be sited at the car park

19. Lorries and tanks used to transport fish should be cleaned by power-hose, rinsed and disinfected before loading and again after each delivery of fish to a farm

20. Bus-stop deliveries of fish by lorry should be avoided ie. single site delivery is recommended

FRS Marine Laboratory, PO Box 101, 375 Victoria Road, Aberdeen, AB11 9DB

TEL: 01224 876544 FAX : 01224 295511

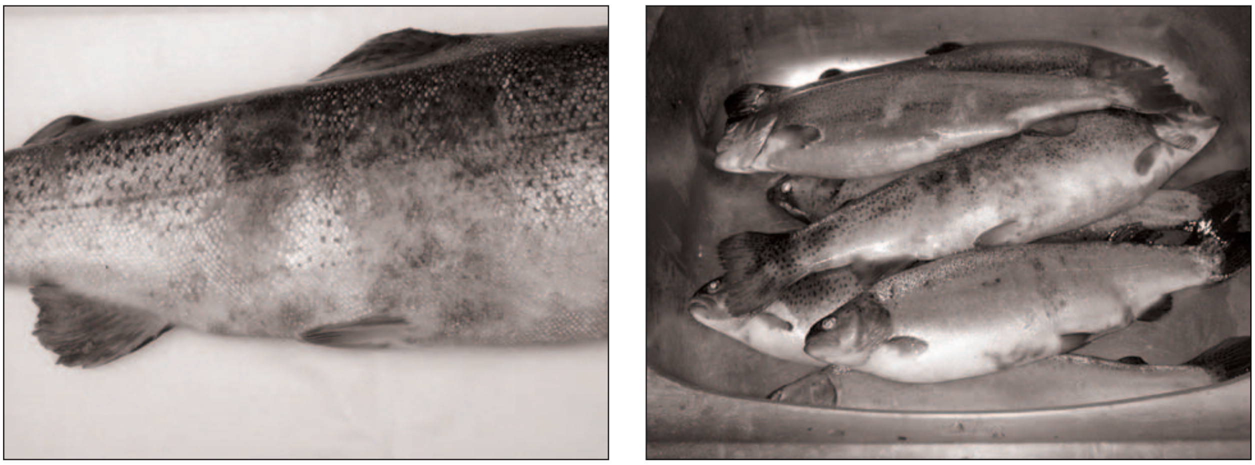
STRAWBERRY DISEASE IN RAINBOW TROUT

Sophie St-Hilaire and Keith Jeffery, CEFAS Weymouth Laboratory, Barrack Road, The Nothe, Weymouth, Dorset. DT4 8UB

Strawberry disease is a summertime skin condition of rainbow trout, which has been described in the United Kingdom, United States, Japan, and France. The disease is characterized by yellow or red (often hemorrhagic) non-raised lesions on the ventral and lateral sides of, predominantly, market size fish (Figure 1). In some cases these areas may be ulcerated. Although this disease does not usually result in mortality, it is of economic concern to the trout industry because affected fish are downgraded or rejected at processing. In the UK, affected farms may have up to 20% of summer harvests affected by the disease, resulting in significant economic losses.

The cause of strawberry disease is unknown. Several researchers have examined affected fish for known fish pathogens, but nothing conclusive has been reported. Some researchers believe strawberry disease is caused by a bacterial pathogen. In our preliminary investigation we did not find systemic infections with bacteria; however, several bacteria types were isolated from the skin lesions. One of these, which was consistent in all affected fish cultured was *Aeromonas hydrophila*. These bacteria are commonly found in the aquatic environment and usually are considered non-pathogenic; however, under certain conditions they can produce toxins. Our histological findings were also consistent with the tissue reaction that would be observed with exposure to a toxin (i.e. inflammatory cell response with no evidence of a pathogen and areas of haemorrhage). These findings have led us to hypothesize that strawberry disease may be a result of a toxin-producing bacterial skin infection. If our hypothesis is correct, then treatment of fish with a surface disinfectant or treatment of the water may reduce the prevalence of the disease.

Pending funding, CEFAS is planning to conduct a clinical trial to assess the efficacy of a number of different treatments for strawberry disease in the summer of 2004. We will be recruiting participants for this project. If anyone is interested in participating in this field trial please contact us (Sophie St-Hilaire or Keith Jeffery) at the CEFAS Weymouth Laboratory (01305 206600).



Figures 1(a) and (b). Strawberry disease in rainbow trout

THE INFLUENCE OF RAIN ON THE FEEDING BEHAVIOUR OF BROWN TROUT

Daniel Bagur, 25 Penrheidol, Penparcau, Aberystwyth, Ceredigion, Wales. SY23 1QW.
Email: drbagur@postmaster.co.uk

This article is based upon an undergraduate research project carried out at Aberystwyth University

My interest in the potential effect of rain on the feeding behaviour of trout was stimulated by a personal experience. While fly fishing for brown trout on Rutland Water, the weather suddenly changed from calm sunshine to a thunderstorm - dark clouds, lightning and extremely heavy rain. With the onset of the stormy conditions, the trout suddenly started to feed voraciously. I caught three fish in rapid succession, but after a few minutes, calm sunshine returned and the fish went off the feed.

There is much anecdotal evidence from anglers that thunderstorms induce feeding in fish. However it is unclear whether this is due to the rain itself, a change in light intensity, the thunder and lightning, or other associated environmental factors. Inspired by this experience, I carried out a series of experiments in the aquatic experimental area at Aberystwyth University, Wales, to examine the effect of rain on the behaviour of brown trout.

Brown trout (*Salmo trutta*) parr (average fork length – 153 mm) were purchased from a local fish farm and maintained in 50 l aquaria. A plastic plant and a broken plant pot were placed in the aquarium to provide cover for the fish to reduce stress and promote as natural a behaviour pattern as possible (Figure 1). Fish were acclimated to the aquaria for ≥3 weeks prior to experimentation and fed trout pellets and frozen bloodworm.

The test tank was identical to the stock tanks except it was marked into three equal sections – upper, middle and lower – to enable visual monitoring of the vertical position of the trout. Rain was simulated via an adapted showerhead supplied with water from within the test aquarium and controlled via a pump. Single trout were added to the test aquarium and left overnight to allow recovery from handling. The vertical position was then recorded during four 15 minute observation periods over a two day period – two periods with no rain and two periods with rain. During one of each of the rain and no rain periods, food (30 bloodworms) was provided. The position of the trout was recorded every 60 seconds during each 15 minute observation period. When a fish was between sections, the section containing the largest proportion of its body was counted. Extreme care was taken not to scare the fish during the observations which were taken from a constant position so that the recorded position of the fish between aquarium sections remained as accurate as possible.

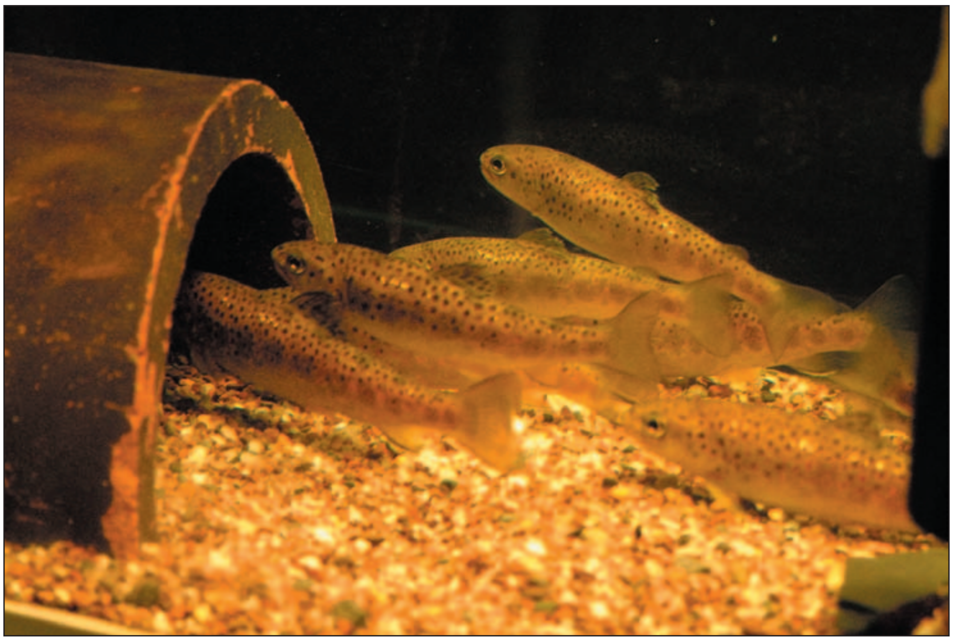


Figure 1. Brown trout parr in stock aquarium

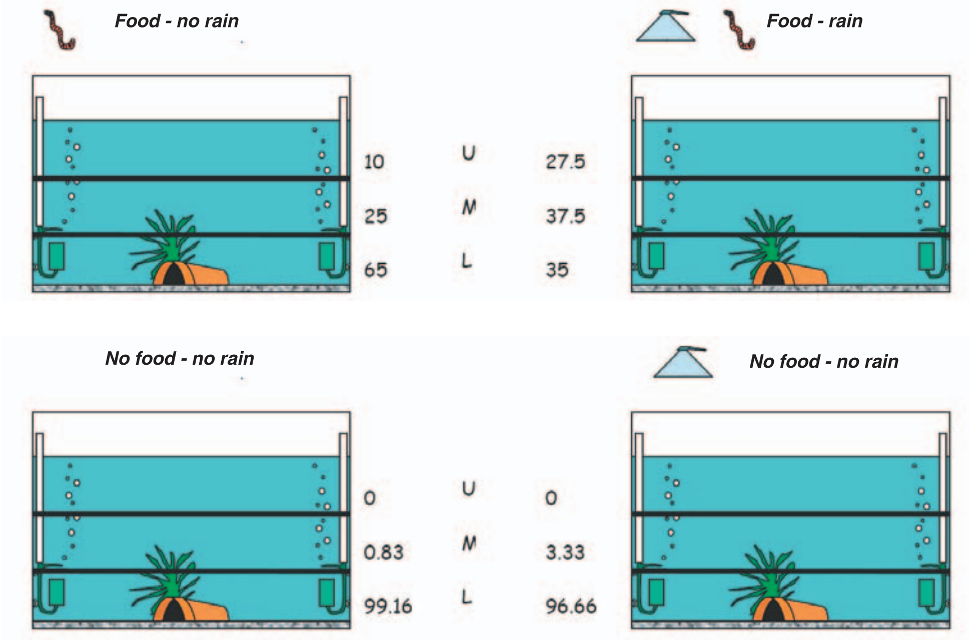


Figure 2. The percentage of time spent by brown trout parr at each of the three depth ranges within the water column

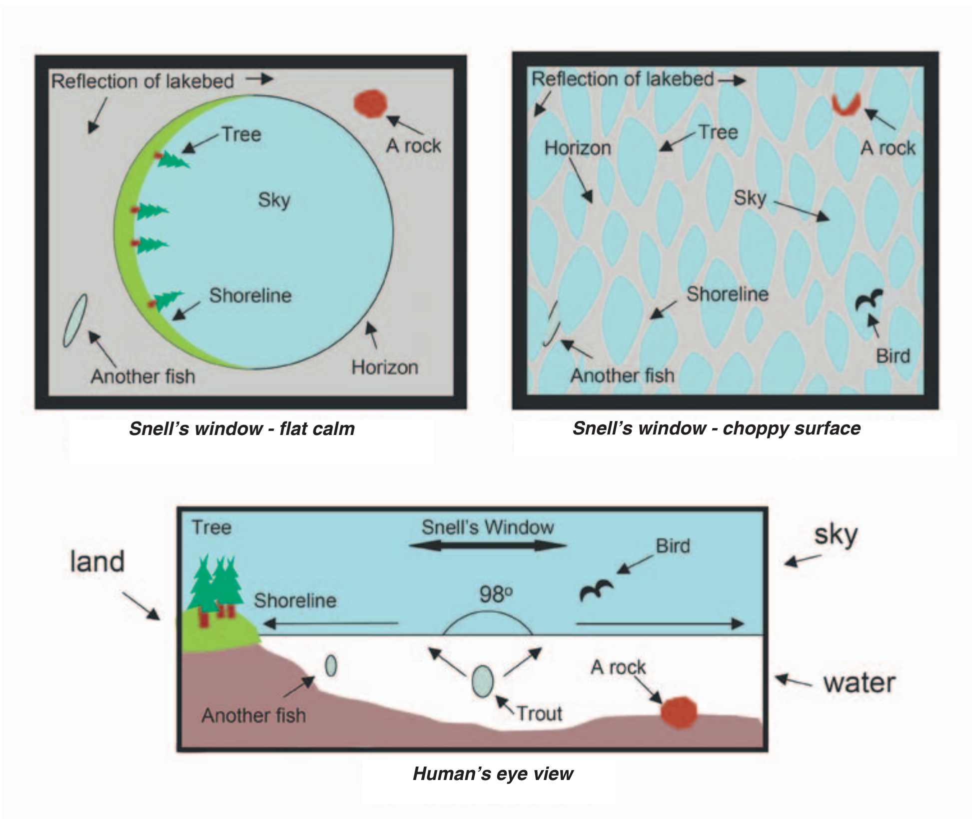


Figure 3. Snell's window (re-drawn from Frost & Brown, 1967).

A fish looking upwards through the air-water interface is thought to view the terrestrial and aerial world through Snell's window. This surface window is approximately twice the diameter of the fish's depth. Deeper fish have a larger window but the objects seen through it are increasingly darker and blurred. Within the window objects appear large and are not confused, but outside the window the trout sees a silvery reflection of the surface along with whatever is in the water. Objects along the horizon such as trees or fishermen (apparently out of the fish's field of vision) are in fact visible to the fish because light striking the surface at an angle within the window are refracted by 98°. In this way the whole of the horizon can be viewed by fish through Snell's window. When the surface is disturbed however, Snell's window is broken up and the fish has a scattered view of the air and land above and around the water. This is advantageous for detecting approaching predatory birds but disadvantageous for viewing the shoreline.

The results of the total number of observations in lower section of the tank ($\log_{10}$ transformed) were analysed by ANOVA . Both the presence of rain and food had a significant effect on the vertical distribution – the trout spent less time in the lower section when there was rain or food. There was also a significant interaction between rain and food – the fish spent the least time in the lower section of the aquarium when rain was combined with food, as illustrated by the time budgets (Figure 2).

The experiment demonstrated that the trout spent less time near the bottom of the tank in the presence of rain. This finding would help explain the increase in catch rate I observed while fishing. The primary factors thought to affect the distribution of fish within a habitat are the availability of food and the risk of predation (Bone, Marshall & Blaxter, 1999). The behaviour shown by the trout would correspond to the fish moving into the surface waters and searching for food.

The surface film acts like a spider's web, conveniently trapping insects for salmonid fish (Pitcher, 1993). The number of insects flying above a large lake at any given time is considerable, and heavy rain may knock additional insects into the surface waters (Pitcher, 1993). Conditions like this could therefore introduce a rare flux and variety of food items into the fish's reach. An alternative hypothesis that fishermen have suggested is that hatchery-reared fish associate rain with food because rain droplets may stimulate a conditioned feeding response to trout pellets landing on the surface.

Piscivorous birds are an important predator of trout and rain would reduce the risk of such avian predators which locate prey by vision. Light intensity would be reduced during rainfall, as the rain clouds themselves would block out the sunlight. The wind associated with rain and the rain droplets would disturb the surface water which would therefore become less transparent, and hinder the birds ability to see the trout. A reduction in vulnerability from avian predators would be served further by the dynamics of 'Snell's window' improving the ability of the fish to see approaching birds. On calm days a predator cannot be seen until it is directly above the fish, but when the surface is broken up, the fish get a scattered view of approaching birds from a greater distance (Pitcher, 1993- see Figure 3).

Rain may also affect the surface environment in other ways beneficial for trout. The associated reduction in light intensity would prevent the fish from glare (Pitcher, 1993) because the eyes of trout are easily damaged by bright sunlight as they lack eyelids. Also, the rain may induce slight increases in oxygen level and temperature of the surface waters, as observed in the experimental tanks.

Rain appears to change the motivational state of fish, resetting the balance between the dangers presented by predators and the effort required to gain a meal. There is no doubt that fish respond to changes within their environment. It could be advantageous for the fish farmer and fishermen to adapt their regimes in order to make the most of the changes these events induce in the feeding behaviour of trout.

Literature Cited

Wootton, R.J. (1999). *Ecology of Teleost Fishes, s*econd edition. Kluwer Academic Publishers.

Pitcher, T.J. (1993). *Behaviour of Teleost Fishes* – second edition. Chapman and Hall.

Bone, Q., Marshall, N.B & Blaxter, J.H.S. (1999). *Biology of Fishes – Tertiary level biology.* Second edition. Stanley Thornes Ltd.

Frost, W.E. & Brown, M.E. (1967). The Trout – The *Natural History of the Brown Trout in the British Isles*. Collins. The Fontana New Naturalist.

INFORMATION FILE

SECOND VETERINARY RESIDUES COMMITTEE ANNUAL REPORT

The second VRC annual report on surveillance for residues of veterinary medicines and other substances was published on 15 December 2003. The report summarises the most interesting results from the Veterinary Medicines Directorate's (VMD) surveillance schemes and explains their significance.

The Veterinary Residues Committee is an independent advisory committee set up in 2001. Its role is to advise the Chief Executives of the VMD and Food Standards Agency on planning surveillance and commenting on the results obtained.

In general very few residues were found in UK produced trout. However, residues of malachite green or its metabolite leucomalachite green were found in 2 of 67 trout samples tested for those substances. The Committee expressed concern that these residues continue to be found. They also say that they wish to see continued surveillance for these substances and would support prosecutions where there is sufficient evidence of the use of malachite green following the announcement by Defra in June 2002 that its use must stop.

The report is available to download from the VRC website – www.vet-residues-committee.gov.uk and the VMD website – www.vmd.gov.uk. Hard copies are available on request from Isabel Sharma on 01932 338330, Email: i.sharma@vmd.defra.gsi.gov.uk, or by writing to:

Secretariat
Veterinary Residues Committee
Woodham Lane
New Haw
Addlestone
Surrey
KT15 3LS

AQUAFLOW: A EUROPEAN NETWORK FOR THE DISSEMINATION OF AQUACULTURE INFORMATION

Aquaflow is a project co-ordinated by the European Aquaculture Society (EAS) and the Federation of European Aquaculture Producers (FEAP), with funding from the European Commission. The main target of the Aqua-flow project is to improve the link between scientists and producers. Over 300 technical leaflets summarising the findings of a variety of aquaculture research programmes and workshops are available on-line (www.aquaflow.org). Recently published technical leaflets include:

TL2003-144: Spawning activity of early and late spawning rainbow trout (*Oncorhynchus mykiss*) strains under light program conditions.

TL2003-145: Towards a molecular genetic tool for health and performance monitoring of Atlantic salmon.

TL2003-151: Zoo-sanitary risks associated with trade and transfer of fish eggs and sperm.

TL2003-152: Sustainable environmental aquaculture feeds.

TL2003-153: Replacing fishmeal by plant protein grown in the EU.

TL2003-156: WAVE Working in Aquaculture, Validation of Experience.

TL2003-163: Increasing fish farming and reducing environmental impact.

TL2003-164: Impacts of cormorant and otter predation on fishponds.

SCOTTISH MODERN APPRENTICESHIP APPROVED FOR AQUACULTURE

A new training programme, designed to give people a valuable insight into aquaculture and gain practical skills and experience, is now available in Scotland. A Scottish Modern Apprenticeship in Aquaculture, initiated by Train Shetland, has been developed by Lantra following significant interest from aquaculture employers, and has been approved by the Modern Apprenticeship Implementation Group.

The Modern Apprenticeship provides a tailored solution to the aquaculture industry's need for employees who can combine technical knowledge with practical skills. Modern Apprenticeships are a route by which people can begin a career in aquaculture, learn practical skills and achieve nationally recognised qualifications. They are government backed training schemes aimed primarily at young people aged between 16-24, however in certain regions funding is available for older people.

Candidates enrolling on the Aquaculture Scottish Modern Apprenticeship will gain the nationally recognised Aquaculture Scottish Vocational Qualification (SVQ), in addition to the Core Skills of communication, working with others, problem solving, IT and numeracy. Apprentices also gain industry-specific certificates appropriate to their own circumstances and the business in which they work, such as Sea Survival, a Fish Vaccination course, or Emergency First Aid.

"We are delighted to have helped the industry to access this benchmark demanded by their Aquaculture Industry Action Plan", says Tricia Bloomfield, Lantra's Industry Partnership Manager for Aquaculture. "The take-up of the Aquaculture Modern Apprenticeship so far is very encouraging and initial feedback from the apprentices is very positive".

For more information about Modern Apprenticeships, contact Karen Lawlor on 02476 858432 or Email: karen.lawlor@lantra.co.uk.

Lantra, the Sector Skills Council for the Environmental and Land-based Sector, is licensed by the UK government to drive forward the new skills, training and business development agenda for the sector. Lantra represents 400,000 businesses and 1.5 million employees in agricultural crops, agricultural livestock, animal care, animal technology, aquaculture, environmental conservation, equine, farriery, fencing, fisheries management, floristry, game conservation, land-based engineering, landscaping, production horticulture, trees and timber and veterinary nursing.

For further information contact
Gemma Pendleton,
Marketing Co-ordinator, Lantra.
Tel: 02476 858414 or
Email gemma.pendleton@lantra.co.uk www.lantra.co.uk.

PRESS RELEASE: NEW CHAIRMAN FOR BTA

Following the British Trout Association's 15th annual conference at Sparsholt College, the Association announced the appointment of its new Chairman Nick Read who takes over from Robin Scott. A trout farmer of almost thirty years' experience and owner of Alderley Trout - the family business now run by his two sons - Nick has been active in the BTA for over twenty years both as Head of Marketing & Promotions and, most recently, as Council Member responsible for Legislation. He takes over in the year that marks the Association's twentieth anniversary.

Of this year's Sparsholt conference, Nick said "It's been a great success. Sparsholt is always a useful place for farmers to meet, but this year the turn-out from working trout farmers has almost doubled. " He views the extremely high standard of the 2003 speakers as a tribute to Professor Niall Bromage, the BTA's technical consultant who died this year, to whose memory the conference was dedicated. "The conference has gained a reputation as a focal point for spreading word of the latest improvements in technology. Niall's work in drawing speakers from all over the world has been invaluable. His extensive international contacts made him a tower of strength for Sparsholt. It's going to be a very hard job to replace him."

Speaking of the future of the British Trout Association, Nick said "It has become increasingly important that the fish farming industry has a strong trade association. It's also essential that the industry continues to rationalise in both production and processing to accommodate the needs of the fast-changing food market. As a product, trout has the necessary attributes to expand its share of the food market but Andrew Cookson's warnings about the future of the industry are well-taken, and it is essential that the need to focus on product development be taken seriously."

As shareholder in Sarum Foods, a recently formed value-added trout and salmon processor specialising in cooked products, Nick is alert to the significance of value-added products to the industry:

"Value-added and convenience products are increasingly important to the industry; there is an absolute requirement for the industry to follow the lead of the consumer. Trout growers are sometimes understandably turned off by phrases like 'consumer-led', but it is vital that we pay attention to what the consumer wants. Bringing BTA PR in-house is helping us to develop a closer understanding of the market, its requirements and concerns.

"On the environmental front, fish farmers are guardians of the river environment: any problem with the water and the fish farmer is the first to know and to alert the authorities. The association has always worked closely with Defra and the Environment Agency and we will continue to build on those relationships.

Nick is the newly appointed Chairman of the Environment Commission of FEAP (the Federation of European Aquaculture Producers), an organisation which he believes will become even more important as the European Trout Market becomes more fluid. "It seems likely that in the future much of the funding for trout research will come from Brussels, which will lead to increased collaboration with other European trout associations." he says. "The BTA has always been a strong supporter of FEAP and FEAP recognises the UK as having a particularly well-organised trade association."

The BTA represents members growing over 80% of the trout grown in the UK and works closely with the Environmental Agencies and devolved regulators both in the UK and in the European Community to ensure that the industry can work within an enabling legislative framework, as well as co-ordinating relevant research and development. Nick Read sees his role as Chairman as facilitating increased co-operation throughout the UK and warns against stagnation. "We've been producing the same tonnage for 15 years. I believe that product development is key to the future success of the industry but the need to reduce the cost of production remains with us: it's the continuation of a long-term trend in food production that has been going on for 200 years. It applies to all foods and trout is no exception."

BTA NEWS

Jane Davis, Executive Officer, British Trout Association

The BTA Press Office activities have centred largely on the production and dissemination of three product information cards entitled *Hot Smoked Trout*, *Trout Fillets: Healthy Fast Food* and *Trout: Rich in Omega-3 Essential Fatty Acids*. The hot smoked trout card was issued to media contacts for the Christmas and New Year season, together with product samples to select contacts. The trout fillet and nutrition cards will be used to promote fillets as healthy fast food and trout as an Omega-3 rich food in the new year, for the spring and summer periods. Press Office activity over the summer concentrated on regional press with barbecue recipes and information on selenium as a potential counter to the harmful effect of the summer sun. *Barbied Trout for a Cool Cook!* and *A Cool Time for Trout* elicited a very positive response. The Press Office devised some simple new leaflets for members' use in farm shops and farmers' markets.

The Environment Agency have recently published *The National Trout and Grayling Strategy*. The BTA will meet with the EA in early January to discuss many of the issues relevant to trout farming raised by this strategy.

It has been reported that Slice, Schering-Plough Animal Health's treatment for sea-lice, which is licensed for use in salmon, has been effective in reducing the incidence of *Argulus* on trout at a stillwater fishery. Currently the use of Slice for trout in freshwater can only be approved under the cascade principle, which entails a 500°day withdrawal period. Separate permission for use (discharge) must additionally be granted by the appropriate environmental agency. It is hoped that approval for the treatment of trout in freshwater will soon be available, to combat the debilitating effects of *Argulus* infestations for fisheries, and the associated welfare implications for freshwater trout.

Defra have recently confirmed their financial support for R&D projects on Whitespot, Stocking Density, and Selective Breeding as put forward by the BTA in the 2002 Committee for Aquaculture Research and Development (CARD) round. These projects are effectively extensions of the work conducted at the Institute of Aquaculture, Stirling. The Association has also recently offered its support for a CEFAS survey concerning the efficacy of screens/leats in relation to the entrapment of wild fish. In a separate call for research from Defra's Animal Health and Welfare Division, the BTA have pledged support for two proposals put forward by Stirling, Bristol and CEFAS concerning fin erosion and water quality parameters in relation to fish welfare. The next CARD meeting, where proposals for forthcoming R&D projects will be heard by Defra, will be held in March/April 2004. As priorities the BTA are considering putting forward project proposals concerning Strawberry Disease, PKD, Environmental Eco-toxicological Data (or lack thereof) and possibly Crayfish Plague.

NATIONAL TROUT AND GRAYLING FISHERIES STRATEGY

The Environment Agency has recently published the National Trout & Grayling Fisheries Strategy. The strategy is founded on the Agency's duty to maintain, improve and develop fisheries within the overall aim of contributing to sustainable development. It is the latest fisheries strategy developed, and there are already separate national fisheries strategies for salmon, coarse fish and eels. The aim of this strategy is to conserve and improve wild stocks of trout, sea trout, char and grayling, while enhancing the environment for all types of fisheries for these species in England and Wales. It also aims to enhance the social and economic benefits derived from these fisheries.

The strategy details how the social and economic benefits from trout and grayling fisheries will be enhanced primarily by promoting angling and strategically developing angling opportunities. Policies are included to help ensure the conservation of stocks of trout and grayling relating to exploitation, stocking, escapes from fish farms, bird predation and habitat.

The strategy was developed through extensive consultation not only with the Agency's Regional Fisheries, Ecology and Recreation Advisory Committees but also with the national fisheries and conservation organisations. A draft strategy was significantly amended on advice received from wider public consultation in 2001. The Strategy can be downloaded from the EA website (www.environment –agency.gov.uk) or a hard copy can be obtained free of charge by contacting Public Enquiries
(Tel: 01454 624411;
Email: enquiries@environment-agency.gov.uk).

A WIDER REMIT FOR *TROUT NEWS*

It is 18 years since *Trout News* was first established and over this time it has served as an outlet for dissemination of research, policy and legislative information to the UK trout farming community. However, the fish farming industry in England and Wales is currently undergoing a period of diversification. There has been a significant growth in the production of finfish species other than salmonids, as highlighted in a previous edition*. Currently over 30 fish farms rear non-salmonid species alongside trout. This diversification has been to support the increasing economic value of the trades in both coarse fish (for restocking) and ornamental coldwater fish. In addition to the UK production, there is also a significant import, both legal and illegal, of non-salmonids. It has therefore been decided to expand the remit of Trout News to reflect these changes. Articles on issues affecting coarse and ornamental cold-water species and their production will be included in future editions, and contributions will be welcomed by the editors.

* Dunn, P. (2003). Survey of finfish production in England and Wales – Five year review. *Trout News* 35, 10-20.

WHERE TO GET HELP AND ADVICE

Policy Matters

Department for Environment, Food and Rural Affairs,
Nobel House, 17 Smith Square, London SW1P 3JR
(Switchboard tel. 020 7238 3000)
(General fax. 020 7238 6591)

Fish farming policy:-
Fisheries Division IIA, Room 308, Nobel House,
(Tel. 020 7238 5947) (Fax. 020 7238 5938)

Grant Aid:-
Fisheries Division 1B, Room 441 Nobel House,
(Tel. 020 7238 5710) (Fax. 020 7238 5951)

Research and Development Programmes:-
Science Directorate, Cromwell House,
Dean Stanley Street, London SW1 3JH
(Tel. 020 7238 3000) (Fax. 020 7238 1590)

You can also visit the Defra website at
www.defra.gov.uk/

The National Assembly for Wales,
Agricultural Policy Division 5,
New Crown Buildings, Cathays Park, Cardiff CF1 3NQ
(Tel. 02920 823567) (Fax. 02920 823562)
www.wales.gov.uk

Scottish Executive of Rural Affairs Department,
Pentland House, 47 Robbs Loan, Edinburgh EH14 1TW
(Tel. 0131 244 6224) (Fax. 0131 244 6313)
www.scotland.gov.uk/who/dept_rural.asp

Department of Agriculture and Rural Development,
Fisheries Division, Annexe 5, Castle Grounds,
Stormont, Belfast, BT4 3PW
(Tel. 028 9052 3431) (Fax. 028 9052 2394)
www.dardni.gov.uk

Scientific and technical advice

Health regulations and disease control -
CEFAS Weymouth Laboratory, Barrack Road,
The Nothe, Weymouth, Dorset DT4 8UB
(Tel. 01305 206673/4) (Fax. 01305 206602)
Email: Fish.Health.Inspectorate@cefas.co.uk

Pollutants and their effects -
CEFAS Burnham Laboratory, Remembrance Avenue,
Burnham-on-Crouch, Essex, CMO 8HA
(Tel. 01621 787200) (Fax. 01621 784989)

You can also visit the CEFAS website at
www.cefas.co.uk

Farm animal welfare -
Department for Environment, Food and Rural Affairs,
Animal Welfare Division, 6th Floor, 1A Page Street
London SW1P 4PQ

Environmental issues -
Environmental Agency, Rio House, Aztec West,
Almondsbury, Bristol, BS32 4UD
(Tel. 01454 624400) (Fax. 01454 624033)
www.environment-agency.gov.uk

Veterinary medicines -
The Veterinary Medicines Directorate,
Woodham Lane, New Haw,
Addlestone, Surrey KT15 3LS
(Tel. 01932 336911) (Fax. 01932 336618)
www.vmd.gov.uk

Food hygiene -
Food Standards Agency
Aviation House, 125 Kingsway, London WC2B 6NH
(Tel: 020 7276 8000)

Advice on commercial activities

The British Trout Association,
8/9 Lambton Place, London W11 2SH
(Tel. 020 7221 6065) (Fax. 020 7221 6049)
www.britishtrout.co.uk

Wildlife conservation

Joint Nature Conservation Committee,
Monkstone House, City Road, Peterborough PE1 1JY
(Tel. 01733 562626) (Fax. 01733 555948)
www.jncc.gov.uk

English Nature,
Northminster House, Peterborough, PE1 1UA
(Tel. 01733 455000) (Fax. 01733 568834)
www.english-nature.org.uk

Countryside Council for Wales,
Ffordd Penrhos, Bangor, LL57 2LQ
(Tel. 01248 385500) (Fax. 01248 355782)
www.ccw.gov.uk

Scottish Natural Heritage
12 Hope Terrace, Edinburgh, Scotland, EH9 2AS
(Tel. 0131 447 4784) (Fax. 0131 446 2277)

Other Useful Numbers

Co-ordinator for Defra - CARD R&D
Dr Mark James, Fisheries Resource Management Ltd,
Coillie Bhrochain, Bonskeid, Pitlochry, Perthshire
PH16 5NP
(Tel/fax. 01796 474473)
www.frmltd.com

RESEARCH NEWS

1. Acute stress can damage the gut lining of fish

In this study groups of Atlantic salmon in either feeding (guts filled with faeces) or fasted (3 days of food deprivation) states were subjected to 15 minutes of acute stress. The acute stress led to significant alterations in the ultrastructure of the cells lining the gastrointestinal tract. The most notable effect was substantial damage in the midgut regions. These effects appeared within the first hour after stress, were maintained for at least 12 hours, and were more pronounced in fed than fasted fish. In contrast, the hindgut was influenced less by stress and damage was rarely observed. Stress also influenced fish intestinal microbiota. Adherent bacteria decreased in both midgut and hindgut of stressed fish, and this was accompanied by a significant increase in the bacterial contents of faeces. It is suggested that this was due to the sloughing of mucus eliminating existing microflora and allowing bacteria (including pathogenic forms) remaining in the gut lumen to colonise the gut lining.

Olsen, R.E. (Institute of Marine Research, Matre Aquaculture Research Station, Matredal, Norway. Email: rolf.erik.olsen@imr.no), Sundell, K., Hansen, T., Hemre, G.I., Myklebust, R., Mayhew, T.M. & Ringo, E. (2002). Acute stress alters the intestinal lining of Atlantic salmon, *Salmo salar* L.: An electron microscopical study. *Fish Physiology and Biochemistry* 26, 211-221.

2. Increased vitamin C intake speeds up healing

This study evaluated the influence of dietary vitamin C on the healing process of experimentally wounded rainbow trout, in order to establish feeding recommendations aiming to reduce the impact of winter sores. Groups of fish were maintained on diets containing either 20, 150 or 1000 mg ascorbic acid (AA) equivalents/kg. Fish were then experimentally wounded, and sampled at various times for histological examination and determination of AA content. Results showed that skin and muscle AA levels were correlated with dietary intake. Of the 22 histological indices evaluated, 13 exhibited significant differences between the three dietary treatment groups. The indices on which dietary vitamin C intake had the greatest affect were generally those containing fibrous tissue, including the repair of damaged dermal fibres, revascularisation and the re-establishment of normal dermal and muscle structure. Of these 13 indices, 7 showed significant differences between the 150 and 1000 mg AA/kg feed groups at some point during the healing process. The majority of the significant histological indices showed a more rapid healing process in the higher two dietary AA treatments, whereas only three showed a faster initial onset of response. The study demonstrates that (1) dietary vitamin C intake influences the rate of wound healing in rainbow trout; (2) increasing the dietary level of vitamin C from 150 to 1000 mg AA/kg feed enables the establishment of larger pools of AA in various tissues; and (3) with larger tissue AA pools, the increased AA demand following wounding does not become a rate limiting step, enabling healing to proceed more quickly.

Wahli, T (University of Bern, Centre for Fish & Wildlife Health, National Fish Disease Laboratory, Laenggassstr 122 POB 8466, CH-3001 Bern, Switzerland. Email: thomas.wahli@itpa.unibe.ch), Verlhac, V., Girling, P., Gabaudan, J. & Aebischer, C. (2003). Influence of dietary vitamin C on the wound healing process in rainbow trout (*Oncorhynchus mykiss*). *Aquaculture* 225, 371-386.

3. Probiotics enhance resistance to ERM

Probiotics are beneficial bacterial cultures which, when added to water or fish feed, improve the health of the host, either by producing antimicrobial substances or by stimulating the host's immune defences. This study examined whether BioPlus2B – a commercial feed additive comprising two bacterial species– affected the survival of rainbow trout exposed to *Yersinia ruckeri*, the bacterial cause of enteric redmouth disease. Three groups of trout were fed either BioPlus2B supplemented feed, Ergosan (a commercial algal product used for immune stimulation) supplemented feed, or control feed, and challenged with *Y. ruckeri* by intraperitoneal injection. The BioPlus2B groups had a lower mortality than either the Ergosan or control groups. Although the basis for this enhanced protection was unknown, there was some evidence that BioPlus2B stimulated the host's immune system.

Raida, M.K., Larsen, J.L., Nielsen, M.E. & Buchmann, K. (Department of Veterinary Microbiology, Section of Fish Diseases, Royal Veterinary & Agricultural University, Stigbojlen 4, DK-1870 Frederiksberg C, Denmark. Email: kub@kvl.dk). (2003). Enhanced resistance of rainbow trout, *Oncorhynchus mykiss* (Walbaum), against *Yersinia ruckeri* challenge following oral administration of *Bacillus subtilis* and *B. licheniformis* (BioPlus2B). *Journal of Fish Diseases* 26, 495-498.

4. Immunostimulation with nucleotides enhances resistance to IPN

Immunostimulants are substances which stimulate the specific and/or non-specific defence systems of fish, enhancing resistance to pathogens. This study on juvenile rainbow trout examined whether nucleotides, added to the diet as an immunostimulant, affected the immune system and the resistance to infectious pancreatic necrosis (IPN). Fish fed a diet enriched with "Optimun" (a commercially available nucleotide mix) showed higher stimulation indexes of both "B" and "T" lymphocytes after 3 months. All normal diet trout injected with IPNV died after one week, whereas all the fish fed the nucleotide enriched diet survived. Results from samples taken from trout infected with IPNV, indicate that the nucleotide diet was able to: a) stimulate "B" lymphocytes and b) decrease plasma cortisol levels. It was concluded that the nucleotide-enriched diet supplied prior to IPNV infections, was able to stimulate the humoral immune response and decrease elevated stress levels, probably caused by the disease.

Leonardi, M. (Concepcion University, Department of Zoology, POB 160-C, Concepcion, Chile), Sandino, A.M. & Klempau, A . (2003). Effect of a nucleotide-enriched diet on the immune system, plasma cortisol levels and resistance to infectious pancreatic necrosis (IPN) in juvenile rainbow trout (*Oncorhynchus mykiss*). *Bulletin of the European Association of Fish Pathologists* 23, 52-59.

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5. Immunostimulation with herbal extracts administered by injection

The immuno-stimulatory effects of Chevimmun, a commercial herbal product combining extracts from three plants (Purple coneflower *Echinacea angustifolia*, common boneset *Eupatorium perfoliatum*, wild indigo *Baptisia tintoria*) was investigated in rainbow trout. A 75% Chevimmun preparation was injected intraperitoneally and various components of the immune system were investigated. The Chevimmun had a significant immunostimulatory effect, increasing the migration of leucocytes, their phagocytic activity, and respiratory burst activity in the peritoneal cavity. Antiprotease activity was also significantly elevated at 2 and 7 days post-injection.

Peddie, S. (Scottish Agricultural College, Department of Agriculture & Food Economics, Aberdeen AB21 9YA, UK) & Secombes, C.J. (2003). The immuno-stimulatory effects of Chevimmun on the rainbow trout (*Oncorhynchus mykiss*). *Bulletin of the European Association of Fish Pathologists* 23, 48-51.

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6. Immunostimulation with herbal extracts in feed

This study investigated the immuno-stimulant effects of various medicinal plant extracts on rainbow trout. Fish were fed with diets containing aqueous extracts of mistletoe *Viscum album*, nettle *Urtica dioica* and ginger *Zingiber officinale* for three weeks and various parameters of non-specific defence mechanisms were examined. The fish fed the diet containing 1% aqueous extract of powdered ginger roots exhibited a significantly enhanced non-specific immune response. Phagocytosis and extracellular burst activity of blood leukocytes were significantly higher than in the control group. The majority of the plant extract diets increased the total protein level in the plasma.

Dugenci, S.K. (Istanbul University, Fisheries Department, Ordu Cad 200, TR-34470 Istanbul, Turkey. Email: skaratas@istanbul.edu.tr); Arda, N. & Candan, A. (2003). Some medicinal plants as immuno-stimulants for fish. *Journal of Ethnopharmacology* 88, 99-106.

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7. VHS-DNA vaccination trials

Rainbow trout of different sizes (10 and 100 g) were injected intramuscularly (i.m.) or intraperitoneally (i.p.) with different doses (range 10ng-10mug) of a viral haemorrhagic septicaemia (VHS)-DNA vaccine (pcDNA3vhsG). Control fish were injected with either the pcDNA3 plasmid alone or with inactivated VHS virus. Fish were challenged at different times post-vaccination (p.v.) to assess protection. A DNA dose of 0.5 mug injected by the i.m. route induced protection in fish of all sizes in challenges performed either 1 or 4 weeks p.v. This dose also conferred effective protection up to 9 months p.v. in fish >100 g. With lower doses of DNA (0.1 and 0.01 mug) and challenge at 4 weeks p.v., 10 g fish were partially protected but protection was not observed in 100 g fish. Vaccination by the i.p. route induced no or lower levels of protection compared with the i.m. route. Fish vaccinated with 0.5 mug DNA i.m. had no detectable serum neutralising antibody (NAb) at 4 weeks p.v. (with the exception of a single 10 g fish) but antibody was detected at 8 weeks and 6 months p.v. but not at 9 months p.v. However, cohorts of these fish showed effective protection at all time points.

McLauchlan, P.E., Collet, B., Ingerslev, E., Secombes, C.J., Lorenzen, N. & Ellis, A.E. (Marine Lab, POB 101, Victoria Rd, Aberdeen, AB11 9DB, UK. Email: ellist@marlab.ac.uk). (2003). DNA vaccination against viral haemorrhagic septicaemia (VHS) in rainbow trout: size, dose, route of injection and duration of protection-early protection correlates with Mx expression. *Fish and Shellfish Immunology* 15, 39-50.

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8. Helminthe worm vaccination trials

This study examined whether vaccination is possible against *Discocotyle sagittata,* a monogean parasite of freshwater salmonid fish which can be an important pathogen of farmed trout. Rainbow trout were injected intraperitoneally with *D. sagittata* extracts and subsequently exposed to controlled infection. Immunisation was partially successful, reducing worm intensities in >50% of the vaccinated fish. Immunised fish had significantly higher specific antibody titres at the time of dissection than both naive and control fish. Overall, a significant negative correlation was found between antibody titres and worm burdens, suggesting immunoglobulins are involved in mediating partial immunity. However, several other non-specific and cellular factors are also likely to be involved in controlling parasite numbers.

Rubio-Godoy, M. (University Bristol, School of Biological Sciences, Woodland Road, Bristol BS8 1UG, Avon, UK. Email: m.rubio-godoy@bristol.ac.uk); Sigh, J; Buchmann, K; Tinsley, RC (2003). Immunisation of rainbow trout *Oncorhynchus mykiss* against *Discocotyle sagittata* (Monogenea). *Diseases of Aquatic Organisms* 55, 23-30.

9. RTFS immunisation trials

Flavobacterium psychrophilum, the causative agent of bacterial coldwater disease (CWD) and rainbow trout fry syndrome (RTFS), causes high mortality in cultured salmonids. This study was designed to determine the role antibodies play in conferring protection by passive immunisation of rainbow trout fry with either convalescent serum, serum from adult rainbow trout immunised with *F. psychrophilum*, or goat anti-*F. psychrophilum* serum. In each experiment, rainbow trout fry were injected intraperitoneally with antiserum and challenged with a virulent strain of *F. psychrophilum* 24 h later. Relative percentage survival (RPS) ranged from 9-42% when fry were injected with convalescent serum. Rainbow trout fry passively immunised with serum from immunised adult fish exhibited RPS values up to 57%. In each of these experiments, RPS increased with increasing antibody titres. However, passive immunisation with the goat anti-*F. psychrophilum* serum did not confer protection to fry. These results suggest that trout antibodies do play a role in conferring protection to *F. psychrophilum*, but antibody alone is unable to provide complete protection.

LaFrentz, B.R., LaPatra, S.E., Jones, G.R. & Cain, K.D. (University of Idaho, Dept Fish & Wildlife Resources, Moscow, ID 83844, USA. Email: kcain@uidaho.edu) (2003). Passive immunization of rainbow trout, *Oncorhynchus mykiss* (Walbaum), against *Flavobacterium psychrophilum*, the causative agent of bacterial coldwater disease and rainbow trout fry syndrome. *Journal of Fish Diseases* 26, 377-384.

10. Factors affecting infection by RTFS bacteria

The ability of *Flavobacterium psychrophilum* to adhere to the gill tissue of rainbow trout was evaluated using an in-vitro gill perfusion model. The adhesion capacity of a high and low virulence bacterial strains was compared and the high virulence strain was shown to attach more readily to the gill. The adherence of the high virulence strain increased when organic material or nitrite was added to the water in which the gill arches were immersed. Elevated temperature reduced adherence of the bacteria to the gills.

Nematollahi, A. (State University of Ghent, Faculty of Veterinary Medicine, Salisburylaan 133, B-9820 Merelbeke, Belgium. Email: amin.nematollahi@rug.ac.be), Decostere, A., Pasmans, F., Ducatelle, R. & Haesebrouck, F. (2003). Adhesion of high and low virulence *Flavobacterium psychrophilum* strains to isolated gill arches of rainbow trout *Oncorhynchus mykiss*. *Diseases of Aquatic Organisms* 55, 101-107.

11. Lack of information on pathogens in US farm effluents

The biological significance of aquatic animal pathogens in fish farm effluents is unknown because there are no reliable, standardised or validated methods for testing effluents for such pathogens. There are internationally accepted analytical methods available to qualify and/or quantify aquatic animal pathogens in tissues which are used in regulatory control programs to limit the introduction of important fish pathogens into new regions. The goal of these programs is to prevent the introduction of significant fish pathogens into the United States, specific states, regions or facilities. These regulatory control programs have been successful at limiting the introduction of important fish pathogens. Additionally, there are health management strategies to minimise the occurrence and impact of disease if it does occur, including the use of vaccines. However, there are currently no consistently used practices to control the discharge of aquatic animal pathogens in effluents of commercial or public aquaculture facilities if pathogens do occur. The most cost-effective way to effectively limit the impact of significant aquatic animal pathogens is to prevent their introduction into facilities.

LaPatra, S.E. (Clear Springs Foods Inc, Res Div, POB 712, Buhl, ID 83316, USA. Email: scottl@clearsprings.com) (2003). The lack of scientific evidence to support the development of effluent limitations guidelines for aquatic animal pathogens. *Aquaculture* 226, 191-199.

12. Effluent management in the US

Minimisation of specific pollutants from US rainbow trout farms is motivated by regulatory requirements and corporate philosophy, but success in reducing discharge of potential pollutants is dependent upon facility design, operation, and financial commitment. In south central Idaho (USA), fish farms are subject to a federal Clean Water Act requiring reduction in phosphorus and suspended solids loads. Total effluent loads of phosphorous must be reduced by 40% from a baseline established in 1991. Suspended solids limits, while not completely determined, are anticipated to need to be maintained at 3-5 mg/l. These reductions must be achieved by 2004. Until 2004, raceway effluent phosphorous must not exceed a mean net concentration of 0.1 mg/l and TSS must not exceed 5 mg/l. Clear Springs Foods has developed a waste minimisation program using practices developed over the past 12 years. These practices rely on application of a disciplined best management practices (BMP) plan, optimization of feeding practices, and use of low-phosphorus feed ingredients. Individual facility-specific BMP plans were developed using a hazard analysis critical control point (HACCP)-like approach that is the focus of this report. Corporate philosophy has embraced the importance of environmental stewardship because of its community benefit and long-term financial implications. These efforts have resulted in a 40% reduction in effluent phosphorus from measured 1990 mass loads. Fish production volumes and fish quality have been maintained and increased costs limited.

MacMillan, J.R. (Clear Springs Foods Inc, POB 712, Buhl, ID 83316, USA. Email: randy@clearsprings.com), Huddleston, T., Woolley, M. & Fothergill, K. (2003). Best management practice development to minimise environmental impact from large flow-through trout farms. *Aquaculture* 226, 91-99.

13. Using wetland to improve effluent quality

The presence of nutrients in the wastewater of salmonid hatcheries is of growing concern to water quality managers. Presently, Washington State regulations require quiescent settling to remove suspended solids from the water but do not as yet address nutrient concerns. In order to evaluate the load of nutrients discharged by salmon hatcheries, the Washington Department of Fish and Wildlife (WDFW) initiated two studies. Water from the Issaquah Hatchery was monitored for total phosphorus for more than a year. Monitoring showed that the hatchery's contribution to watershed phosphorus levels was low and that the primary phosphorous input from the hatchery appeared to be the process water as opposed to water from the off-line settling system. A constructed wetland was installed at the Dungeness Hatchery in order to evaluate it's efficacy in removing nutrients from a conventional offline settling system. Over the course of 4 years of monitoring, the wetland removed most of the solids, phosphorus, and nitrogenous compounds, which resulted in a reduction in biological oxygen demand (BOD). At times, the offline settling system actually increased the level of some of the nutrients, suggesting that treatment of hatchery effluent will need to include a combination of quiescent settling, constructed wetland, and some sort of process water treatment if anthropogenic solids and nutrients are to be more completely removed. The constructed wetland also provided habitat used by amphibians and birds for breeding and foraging. At facilities in locations with sufficient land base available to develop a constructed wetland, it should be possible to reduce the nutrient input to receiving waters and provide additional habitat for aquatic animals.

Michael, J.H. (Washington Dept Fish & Wildlife, 600 Capitol Way N, Olympia, WA 98501, USA michahhm@dfw.wa.gov) (2003). Nutrients in salmon hatchery wastewater and its removal through the use of a wetland constructed to treat off-line settling pond effluent. *Aquaculture* 226, 213-225.

14. Genetic selection for feed conversion efficiency reviewed

Feed conversion efficiency (FCE) is the effectiveness with which feed is converted to saleable fish product. As feed costs are a major input to aquaculture production systems, genetic improvement in FCE may have an important influence on profitability. FCE is usually expressed by a composite measure that combines feed intake and growth rate. The two most common measures are feed conversion ratio (feed intake/weight gain over a specified time interval) and its inverse, feed efficiency. Feed conversion ratio and feed efficiency are measures of gross FCE, because they do not distinguish between the separate energy requirements of growth and maintenance. There is abundant evidence of substantial genetic variation in FCE and its component traits in terrestrial livestock species and, although data are few, the same is likely for cultured fish species. The major problems with selecting from this variation to genetically improve FCE in fish species are: 1) It appears impractical to measure feed intake on individual fish, so that family mean data must be used. 2) We do not know the optimal time period over which to test fish for FCE. 3) We do not know the genetic correlations between FCE under apparent satiation or restricted intake conditions, or between FCE at different times in the production cycle. If these problems can be overcome, selection to improve FCE might be best achieved by measuring feed intake of growing animals, and by utilising genetic correlations that are likely to exist between feed intake and other production traits to develop a weighted selection index.

Doupe, R.G. (Murdoch University, Fish Health Unit, Division of Veterinary & Biomedical Science, Murdoch, WA 6150, Australia) & Lymbery, A.J. (2003). Toward the genetic improvement of feed conversion efficiency in fish. *Journal of the World Aquaculture Society* 34, 245-254.

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15. Dietary plant protein can affect trout broodstock fertility and progeny growth and sex ratio

In this study five rainbow trout broodstocks were fed experimental diets in which fishmeal protein was variably replaced with cottonseed meal (CS) protein (0%, 25%, 50%, 75%, and 100%) for a 22-month period. The effect of increasing dietary levels of CS on reproductive performance of the broodstock was gender specific. Sperm fertilising ability significantly decreased when CS exceeded 50% protein replacement. In contrast, in females, the viability of embryos was only significantly affected at 25% and 50% replacement levels. Progenies from multiple parents per dietary treatment were combined and reared on a commercial diet over a 2- or 3-month period. The paternal origin had a highly significant effect on growth performance of progenies, and progenies from males fed with 25%, 50%, and 75% CS grew significantly ($P<0.05$) faster than progenies from males fed with 0% and 100% CS. Progenies from females fed a diet containing 50% CS grew significantly slower than the other groups. Sex ratio was examined histologically after completion of feeding experiments with progenies. Regardless of maternal or paternal origin, males dominated among the progenies. Thus, it was postulated that other substances such as flavonoids, present in the CS and possibly transferred to yolk sac reserves, might affect the sex ratio in favour of males.

Rinchard, J., Lee, K.J., Czesny, S., Ciereszko, A. & Dabrowski, K. (Ohio State University, School of Natural Resources, 2021 Coffey Rd, Columbus, OH 43210, USA. Email: dabrowski.1@osu.edu) (2003). Effect of feeding cottonseed meal-containing diets to broodstock rainbow trout and their impact on the growth of their progenies. *Aquaculture* 227, 77-87.

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16. Effect of growth on flesh quality

The effect of seasonal variation in growth on fillet quality parameters was investigated in immature Atlantic salmon. Good growth was associated with low fillet lipid and protein level, in addition to reduced levels of fillet tocopherol and astaxanthin, indicating increased oxidative stress. Elevated levels of thiobarbituric reactive substances (TBARs) further supported this. Slaughtering during periods of high growth may therefore reduce post-mortem quality, both because of increased susceptibility to fillet lipid peroxidation and reduced astaxanthin levels, which were lowered in vivo and might consequently be depleted further after slaughter. Specialised use of antioxidant-rich feed prior to slaughter is suggested if slaughtering is expected to occur during periods of high growth rate.

Nordgarden, U. (Institute for Marine Research, Department of Aquaculture, Matre Aquaculture Research Station, N-5984 Matredal, Norway. Email: ulla.nordgarden@imr.no), Ornsrud, R., Hansen, T. & Hemre, G.I. (2003). Seasonal changes in selected muscle quality parameters in Atlantic salmon (*Salmo salar* L.) reared under natural and continuous light. *Aquaculture Nutrition* 9, 161-168.

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17. Levels of mercury in UK-farmed fish much lower than in imported fish

Total mercury concentrations were measured in fish imported into the UK and also in UK-produced farmed salmon and trout. 336 samples were collected using a two-stage sampling plan weighted to reflect consumption, but with some bias towards fish that might accumulate higher levels of mercury, such as large predatory fish at the top of the food chain. Mercury concentrations in UK-farmed salmon and trout were relatively low – the maximum concentration found in 46 samples of fresh/frozen or smoked trout and salmon was 0.103 mg/kg. The highest levels of total mercury were found in billfish (swordfish and marlin) and shark. Mercury concentrations in the 5 samples of fresh/frozen shark ranged from 1.006 to 2.200 mg/kg, all above the European Commission limit for the species. Concentrations in 20 samples of fresh/frozen billfish ranged from 0.153 to 2.706 mg/kg with 13 samples above the 1.0 mg/kg limit for the species. One sample of fresh/frozen tuna out of the 20 collected had a mercury concentration above the limit of 1.0 mg/kg (1.5 mg/kg), but all other fresh tuna samples were well within the regulatory limit (average 0.4 mg/kg). Mercury concentrations in canned tuna were lower with concentrations on average half that measured in fresh/frozen tuna

Knowles, T.G. (University of Bristol, School of Veterinary Science, Bristol, BS40 5DU, UK. Email: Toby.Knowles@bris.ac.uk); Farrington, D. & Kestin, S.C. (2003). Mercury in UK imported fish and shellfish and UK-farmed fish and their products. *Food Additives and Contaminants* 20, 813-818.

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18. An "electronic nose" for determination of flesh quality

The suitability of the 'Cosmos' instrument (Japan) which determines smell intensity was applied to the evaluation of fish quality in six species of different origins. Pond-raised fish (trout, carp, silver perch, tilapia, barramundi) were stored in ice for 4-5 weeks and frozen/thawed mackerel were kept at room temperature for 74 hours. The fish quality was examined by organoleptic assessment, by tests of the chemical (total volatile basic nitrogen, hypoxanthine and histamine) and dielectric (Torrymeter) properties, and determination of smell intensity. Strong correlation was found between the organoleptic and 'Cosmos' results, whereas the data from the chemical and Torrymeter analyses were relatively poorly correlated with the sensory evaluation and 'Cosmos' data. Thus the application of the 'Cosmos' instrument for objective quantitative evaluation of fresh and chilled fish quality by determination of smell intensity seems practicable. The 'Cosmos' instrument is hand-held and portable as well as being rapid and non-destructive in operation; therefore it could be used for evaluation of fresh and chilled fish in the field and on board fishing vessels.

Gelman, A. (Kimron Veterinary Institute, Fishery Products Lab, POB 12, IL-50250 Bet Dagan, Israel. Email: alexander_gelman@hotmail.com), Drabkin, V., Glatman, L. (2003). A rapid non-destructive method for fish quality control by determination of smell intensity. *Journal of the Science of Food and Agriculture* 83, 580-585.

19. Morphine analgesia of trout provides further evidence that fish feel "pain"

Recent anatomical and electrophysiological studies have demonstrated that fish are capable of nociception - the simple detection of a noxious, potentially painful stimulus and the reflex response to this. However, to prove pain perception, it must be demonstrated that an animal's behaviour is adversely affected by a potentially painful event and this must not be a reflex response. The present study examined the acute effects of a noxious chemical administered to the lips on the behaviour and physiology of rainbow trout and presents new data on morphine analgesia in fish. The noxious treatment markedly increased the gill ventilation rate. The noxiously treated individuals did not differ from control untreated individuals in swimming activity or use of cover, but did perform anomalous behaviours - rocking from side to side on either pectoral fin and rubbing their lips against the gravel and sides of the tank. Administering morphine significantly reduced the gill ventilation rate and pain-related behaviours and thus morphine appears to act as an analgesic in the rainbow trout. It is concluded that these pain-related behaviours are not simple reflexes and therefore there is the potential for pain perception in fish.

Sneddon, L.U. (University of Liverpool, School of Biological Sciences, Biosciences Building, Liverpool, L69 7ZB, UK. Email: lsneddon@liverpool.ac.uk) (2003). The evidence for pain in fish: the use of morphine as an analgesic. *Applied Animal Behaviour Science* 83, 153-162.

20. Humane slaughter of trout

The most common commercial slaughter method for portion-sized rainbow trout is asphyxiation in ice slurry. However, this method is widely believed to expose the fish to unnecessary pain and suffering. The industry is consequently seeking an alternative method which offers improved welfare of the fish at slaughter. Electric stunning of fish in water is identified as a suitable method. Parameters of an electric field that stuns trout beyond the point of recovery without causing carcass damage have been identified. A 60-s exposure to a 1000-Hz sinusoidal electric field of 250 V/m r.m.s. is recommended. Several practical options for implementing this method on commercial trout farms are identified and equipment for one of these approaches has been built and tested. The UK trout industry appears to be moving towards electric stunning as its preferred slaughter method.

Lines, J.A. (Silsoe Research Institute, Wrest Park, Silsoe, Beds MK45 4HS, UK. Email: jeff.lines@bbsrc.ac.uk), Robb, D.H., Kestin, S.C., Crook, S.C. & Benson, T. (2003). Electric stunning: a humane slaughter method for trout. *Aquacultural Engineering* 28, 141-154.

21. Transgenic fish reviewed

Over the past 15 years researchers have generated stable lines of several species of transgenic fish important for aquaculture. Growth hormone (GH) gene constructs and antifreeze protein (AFP) genes have been successfully introduced into the fish genome resulting in a significant acceleration of growth rate and an increase in cold and freeze tolerance. However, neither gene modification is completely understood and there are still questions to be resolved. Expression rates are still low, producing variable growth enhancement rates and less than desired levels of freeze resistance. Transgene strategies are also being developed to provide improved pathogen resistance and modified metabolism for better utilisation of the diet. Additional challenges are to tailor the genetically modified fish strains to prevent release of the modified genes into the environment.

Zbikowska, HM (Clearant Inc, 401, Gaithersburg, MD 20879, USA. Email: zbikow@biol.uni.lodz.pl) (2003). Fish can be first - advances in fish transgenesis for commercial applications. *Transgenic Research* 12, 379-389.

22. Trout first in bioengineering

Germ cell transplantation has tremendous applications in transgenic animal production, assisted reproductive technology, and germline stem cell research. This study reports, for the first time in animals, the production of individuals from intraperitoneally transplanted primordial germ cells (PGCs) in rainbow trout. To trace the behaviour of exogenous PGCs in recipients, donor PGCs were visualised by a green fluorescent protein gene. The donor PGCs were prepared from the genital ridges of hatching embryos and transplanted into recipients at various developmental stages. The PGCs injected into the peritoneal cavities of hatching embryos migrated toward and colonised the genital ridges of recipient embryos. Furthermore, donor-derived PGCs proliferated and differentiated into mature eggs and sperm in the allogenic gonads. The resulting gametes produced live fry through fertilisation, showing the donor-derived phenotype. Combined with in vitro culture, genetic modification, and cryopreservation of PGCs, this technique provides new approaches for fish bioengineering.

Takeuchi, Y., Yoshizaki, G. (Tokyo University of Fisheries, Department of Aquatic Biosciences, Minato Ku, 4-5-7 Konan, Tokyo 1088477, Japan. Email: goro@tokyo-u-fish.ac.jp) & Takeuchi, T. (2003). Generation of live fry from intraperitoneally transplanted primordial germ cells in rainbow trout. *Biology of Reproduction* 69, 1142-1149.

23. Cryopreservation of sperm from sex-reversed males

The production of sex-reversed male rainbow trout profits the aquaculture industry allowing the production of “all female” stocks. Female production is preferable since they become sexually mature a year later than males, therefore reaching market size before maturation. Sex-reversed rainbow trout have a similar external morphology to normal males but lack sperm ducts, meaning that the animals must be sacrificed to obtain the milt. The peculiarities of this sperm obtained directly from the testes, make the development of a specific cryopreservation protocol necessary. This study examined several factors that could affect the freezability of the sperm: the season of extraction, the method of extraction, and activation with motility stimulators. The results showed that seasonality clearly affects the success of the cryopreservation process, which should always be carried out with sperm obtained in winter, the natural breeding season. The development of a clean sperm extraction method significantly improved the fertility rates obtained with cryopreserved sperm. The addition of methylxanthines as motility stimulators usually increased motility and fertility rates, but did not provide significant improvements.

Robles, V., Cabrita, E., Cunado, S. & Herraez, M.P. (University of Leon, Department of Cell Biology & Anatomy, E-24071 Leon, Spain. Email: dbcmho@unileon.es) (2003). Sperm cryopreservation of sex-reversed rainbow trout (*Oncorhynchus mykiss*): parameters that affect its ability for freezing. *Aquaculture* 224, 203-212.

24. Effect of photoperiod on trout

An experiment was carried out to determine the effects of different photoperiods on feed intake and growth performance of young rainbow trout. Groups of fish (35 g initial weight) were exposed to a natural photoperiod, a long light period (16L/8D) or continuous light (24L/0D) for 60 days and fed to satiation twice a day. The growth rate, daily feed intake and feeding rate in the natural photoperiod were significantly lower than in the long and continuous photoperiod groups. Growth was highest in the continuous photoperiod, but did not significantly differ from the long photoperiod. The feed conversion ratio, feed efficiency and gross efficiency in the long and continuous photoperiods were 5-7% better than the natural photoperiod. Survival was not significantly affected by the treatment. The study indicates that a long light period improves growth and food conversion rate in young rainbow trout.

Ergun, S., Yigit, M. (Ondokuz Mayis University, Faculty of Fisheries, Aquaculture Department, TR-57000 Sinop, Turkey. Email: muratyigit@ttnet.net.tr) & Tucker, A. (2003). Growth and feed consumption of young rainbow trout (*Oncorhynchus mykiss*) exposed to different photoperiods. *Israeli Journal of Aquaculture-Bamidgeh* 55, 132-138.

25. Effect of turbidity on trout feeding behaviour

The feeding behaviour of juvenile rainbow trout was studied in laboratory tanks under various turbidity and light conditions. The feeding rate on small or large prey was not reduced by high turbidity levels, although high turbidity did reduce the tendency to select larger prey. Some prey were consumed in the complete absence of light, showing trout are able to capture these prey without visual cues. It is therefore apparent that trout use other senses such as the lateral line system to detect and capture prey when turbidity levels are high and when light levels or water clarity are low. This ability is expected to offset any reduction in visual feeding caused by increased turbidity.

Rowe, D.K. (National Institute for Water & Atmosphere Research Ltd, POB 11 115, Hamilton, New Zealand. Email: d.rowe@niwa.cri.nz); Dean, T.L., Williams, E. & Smith, J.P. (2003). Effects of turbidity on the ability of juvenile rainbow trout, *Oncorhynchus mykiss*, to feed on limnetic and benthic prey in laboratory tanks. *New Zealand Journal of Marine and Freshwater Research* 37, 45-52.

26. Personality types in trout

Individual hatchery-reared rainbow trout could be ascribed a “personality trait” of either bold or shy by measuring activity in a test aquarium and the amount of time spent in an exposed open area. The two personality types differed in their feeding behaviour-bold fish would wait in the open to capture pellets at the water surface, while shy fish waited in a covered area and capture pellets in midwater. The personality traits were related to learning ability - bold individuals learnt to associate a light cue with food provision more quickly than shy fish.

SNEDDON, LU (University of Liverpool, School of Biological Sciences, Biosciences Building, Liverpool L69 7ZB, UK. Email: lsneddon@liv.ac.uk) (2003). The bold and the shy: individual differences in rainbow trout. *Journal of Fish Biology* 62, 971-975.

27. Salmonids can learn just by watching

This laboratory study examined social learning in Atlantic salmon. Hatchery-reared parr were trained to feed on live prey from the surface or from the tank floor. Naïve fish were then allowed to observe the trained demonstrators through a clear Perspex partition, without being given access to live prey. After 6 days observation, the foraging skills of the naïve observers were tested. The results revealed that reared salmon can be taught to target benthic prey items by observation alone. The study indicates that such social learning could be used to increase benthic foraging success and hence improve the post-release survival of hatchery fishes

BROWN, C. (University of Edinburgh, ICAPB, Kings Building, West Mains Road, Edinburgh EH9 3JT, UK. culumbrown@yahoo.com), MARKULA, A. & LALAND, K. (2003). Social learning of prey location in hatchery-reared Atlantic salmon. *Journal of Fish Biology* 63, 738-745.

28. Self-feeder response interval

This study examined the effect of varying response intervals - 2, 4, 15, or 60 s - of a self-feeding system on growth and feeding profiles of rainbow trout fry over a 49 day period. In all groups, feeder activation occurred exclusively during the light period with marked peaks at the artificially induced dawn and dusk. As the experiment progressed, the number of feeder activations during peak periods significantly increased in the 2 and 4 s response interval groups, but not the 15 and 60 s groups. As the experiment progressed, the amount of feed dispensed in the 15 and 60 s groups gradually became less than the 2 and 4 s groups. There were significant negative relationships between the response interval and the feeding rate, final body weight, specific growth rate, and condition factor. The study indicates that long response intervals (≥15 s) with the self-feeder and reward level combination significantly restrict the ability of fish to increase the number of feeder activations to satisfy their energy requirements.

SHIMA, T. (Marine Ecology Research Institute, Cent Lab Onju Ku, Chiba 2995105, Japan. Email: shima@kaiseiken.or.jp), YAMAMOTO, T., FURUITA, H. & SUMIKI, N. (2003). Effect of the response interval of self-feeders on the self-regulation of feed demand by rainbow trout (*Oncorhynchus mykiss*) fry. *Aquaculture* 224, 181-191.

29. Comparison of survival and growth of stocked diploid and triploid trout

The objective of this study was to determine whether triploid rainbow trout grew faster or lived longer than diploid rainbow trout after stocking into two south-eastern Idaho reservoirs. In October 1996 triploid and diploid trout were differentially marked and stocked in equal proportions. Relative survival and growth rates were estimated by means of gill-net and electrofishing samples collected through October 2000. In both reservoirs, the relative survival rate (total catch) was significantly higher for triploid fish. The final catch ratios (triploid: diploid) were 1.4:1 and 1.9:1 in the two reservoirs. There were also ontogenetic differences in growth. At age 1, mean lengths and weights were similar for the triploid and diploid fish in each reservoir. During the second year, diploids weighed significantly more than triploids. The trend reversed as the diploid fish matured: age-3 and older triploids matched or exceeded diploid fish in length though not in weight. These findings suggest that while managers considering the use of triploid rainbow trout for trophy management should not expect a consistent growth advantage, such use may extend the period that a specific stock of fish is susceptible to anglers.

TEUSCHER, D.M. (Idaho Department of Fish & Game, 1345 Barton Rd, Pocatello, ID 83204, USA. Email: dteuscher@idfg.state.id.us); SCHILL, D.J., MEGARGLE, D.J., DILLON, J.C. (2003). Relative survival and growth of triploid and diploid rainbow trout in two Idaho reservoirs. *North American Journal of Fisheries Management* 23, 983-988.

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