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Articles, letters and news relating to trout farming are always welcome and may be included in future issues.

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CONTENTS Page

TROUT PRODUCTION

2002 SURVEY OF TROUT PRODUCTION IN ENGLAND AND WALES

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During the first half of 2003, all salmonid farms in England and Wales were visited by Fish Health Inspectors as part of the monitoring programme for maintenance of our approved zone status under the European Council Directive 91/67/EC. Fish farmers are requested to supply production data for the previous year during these inspections. A total of 258 registered salmonid farm sites were visited during the period. Of this total there were 18 sites which reported no sales of fish during 2002, but continued to hold stock, and one site where a recent ownership change meant that data for the previous year was unavailable.

During 2002, 10 new salmonid farms were registered and 14 sites ceased trading and were de-registered. Only a few of these sites reported production. The data included in this report and provided by the site owners therefore represents the production from a final total of 253 registered salmonid farms in England and Wales.

Rainbow trout production

A summary of the production details for all sites farming rainbow trout is presented in Table 1. The sites are grouped according to regional divisions of the Environment Agency, to allow comparison with previously published data. Sites are classified into one of four different categories as follows:

1) Sites that did not produce any rainbow trout during 2002

2) Sites that produce rainbow trout for the table market only

3) Sites that produce rainbow trout for restocking fisheries and/or for ongrowing

4) Sites that cater for both table and restocking/ ongrowing markets.

The total annual production of rainbow trout for the table market in 2002 was 6,357 tonnes from 86 farm sites. This figure is a slight fall compared to 2001 (6,563 tonnes). A total of 181 farms produced rainbow trout for restocking fisheries or ongrowing purposes, which is a decrease of two sites on the 2001 numbers. These sites together produced 3,302 tonnes during 2002, of which 2,883 tonnes were restocking trout and 419 tonnes were fingerlings or yearlings for ongrowing. This figure represents almost an 8% increase on the total restocking and ongrowing production recorded for 2001 (3,062 tonnes). The recorded production of rainbow trout for the table market has decreased by 3% from the last year while restocking production has increased by 17%.

The overall rainbow trout production (combining table and restocking/ongrowing figures) for England and Wales in 2002 was 9,659 tonnes, an increase of 34 tonnes on 2001 production. This suggests that the industry appears to have maintained stability despite problems with the Foot and Mouth Disease outbreak in 2001. The data suggest that sales of live trout fell in 2001 probably

Table 1. 2002 Rainbow trout production by Environment Agency Region for England and Wales

Environment Agency Area	Number Of Sites					Production		
	No Production	Table Production	Restocking/ Ongrowing Production	Both (Table & Restocking)	Total number of sites	Table (tonnes)	Restock/ Ongrowing (tonnes)	Fry (thousands)
Anglian	0	1	9	1	11	21	261	40
North East	2	5	16	11	34	1,035	531	7,896
North West	3	3	5	6	17	108	141	35
Midlands	3	1	11	1	16	9	269	161
Southern	2	4	19	6	31	1,553	226	473
South West	7	11	35	17	70	2,751	1,345	2,632
Thames	2	2	8	7	19	613	307	836
Welsh	0	4	23	6	33	268	221	3,038
Totals	19	31	126	55	231	6,357	3,302	15,110

Table 2. Analysis of rainbow trout and brown trout production according to region and scale of farm output. (The number of farms involved in each size class are given in brackets)

Environment Agency Area	Production according to farm output category (tonnes)				
	0-10	11-50	51-100	101-200	>201
Anglian	12 (4)	127 (5)	143 (2)	0 (0)	0 (0)
North East	60 (16)	298 (10)	443 (6)	305 (2)	550 (1)
North West	31 (10)	151 (5)	90 (1)	0 (0)	0 (0)
Midlands	32 (14)	83 (4)	61 (1)	120 (1)	0 (0)
Southern	70 (19)	241 (9)	0 (0)	0 (0)	1,539 (4)
South West	95 (26)	682 (26)	799 (12)	720 (5)	2,215 (3)
Thames	22 (8)	159 (6)	147 (2)	133 (1)	498 (2)
Welsh	70 (28)	157 (8)	243 (4)	105 (1)	0 (0)
Totals	392 (125)	1,898 (73)	1,926 (28)	1,384 (10)	4,802 (10)
% Total Production	3.8	18.2	18.5	13.3	46.2
% Farms involved	50.8	29.7	11.4	4.1	4.1

as a result of Foot and Mouth Disease reducing the restocking market. The excess fish appear to have been sold to the table market, with an inevitable loss of profit. The data for 2002 in this report demonstrates the return of the live fish market and production returning to previous levels, and table production falling accordingly. In 2001 Table production had increased by 14% while restocking production decreased by 10% on the previous year's figures.

Table 2 provides a breakdown of trout production where farms are classified according to their scale of production. Data for brown trout production are also included because the majority of brown trout are produced from sites also farming rainbow trout. Fry production is recorded in thousands rather than by weight as the latter measure tends to seriously under-represent the value of that production.

Just over 50% of the trout farms in England and Wales are in the 0-10 tonnes category but their combined output only accounts for 3.8% of total production. This is a decrease from 2001 levels in both numbers and production percentage. The numbers of registered small farms during 2002 has decreased by 22 from 2001, while the numbers of slightly larger (51-100 tonne) farms and the largest farms (>201 tonnes) has increased by two sites. The biggest farms (those producing over 200 tonnes annually) account for around 46% of total trout production but form 4% of the total number of trout farms in England and Wales. This part of the industry unsurprisingly appears the most stable. The South West area contains the highest number of farms (72) and produces the most trout of any region (just over 43% of trout production) in England and Wales.

Production of other farmed salmonids

The 2002 production information for brown trout and Atlantic salmon is summarised in Table 3. Of the 258 registered salmonid farms producing fish during 2001, 112 sites produced brown trout in addition to rainbow trout and 18 sites produced brown trout only (a total of 130 sites – a decrease of 1 site from 2001). Ten farms produced both trout and Atlantic salmon, 15 sites concentrated on producing salmon alone, and six farms holding salmon did not record any production. Total production of brown trout in England and Wales has increased to 683 tonnes - an increase of 167 tonnes on the 2001 production which includes 330 tonnes produced for the Table. This is the first time such a significant amount of brown trout has been reported as for the Table market. Only one site recorded brook trout (*Salvelinus fontalinus*) production in 2002, with a single tonne being recorded as produced for the table market while none were produced for ongrowing or restocking purposes. A single site produced Arctic charr, although the production of this species is still not significant (just over 2.5 thousand fish for Ongrowing) and it would appear that trials for producing this species have been unsuccessful.

Commercial units that supply farms in Scotland produced the majority of salmon smolts. A total of 2.2 million smolts were produced from 12 sites. This is the same amount as for 2001 and three more sites have moved into this type of production during the period. Five commercial sites also produced just over 250 thousand salmon parr. In addition, six Environment Agency salmonid rearing sites operated during 2002 to produce fry and juvenile salmon for specific river

Table 3. 2002 production of brown trout and Atlantic salmon in England and Wales

Environment Agency Area	Brown trout				Atlantic salmon			
	Total number of Sites	No. of sites with active production	Restocking/ Ongrowing (tonnes)	Fry (thousands)	No. of sites	Post Smolts (tonnes)	Parr/Smolts (thousands)	Fry (thousands)
Anglian	4	4	32	0	2	1	1	310
North East	18	13	83	81	3	0	511	350
North West	8	3	23	0	5	0	1,891	2,644
Midlands	11	9	18	110	2	0	0	30
Southern	25	22	54	42	3	0	0	563
South West	35	26	84	153	3	0	0	18
Thames	12	11	36	907	3	0	28	0
Welsh	17	15	23	29	6	0	208	268
Totals	130	103	353	1,322	27	1	2,639	4,183

stock enhancement programmes. These sites together produced just over 105 thousand salmon smolts, 135 thousand salmon parr, almost 682 thousand salmon fry and 61 thousand sea trout fry. The numbers of salmon smolts produced by the EA sites has slightly decreased while the numbers of fry produced has more than trebled from last year's total. The numbers of sea trout has decreased by just over 20% on last years production. The changes in production from these sites suggest that the emphasis of salmon stock management is continuing a move towards the use of younger fish while maintaining the emphasis on habitat improvement programmes. The large increase in salmon fry production is especially of interest. The emphasis on brown trout stock management appears to have continued to move away from the release of juvenile fish into river systems.

Ova production

The recorded figures for salmonid ova produced over the period running from late 2002 through to early 2003 from sites holding broodstock are summarised in Table 4. The majority of rainbow trout eggs produced were all-female. Production of this type of egg totalled 20.5 million eggs, of which almost 4.5 million were sold to other sites. These figures represent a decrease of almost 28% from the 2001/2002 season (28.5 million eggs) - and a return to previous levels of production after last year's large increase. It would appear that in 2001 farms used unsold stock as brood fish and laid down their own eggs rather than importing eggs. There was a corresponding fall in numbers of eggs imported in corroboration of this theory. Mixed-sex rainbow trout egg production has remained at last years levels of

Table 4. 2002/2003 eyed ova production from sites holding broodstock salmonids in England and Wales (not including sea trout and salmon produced from wild broodstock by the EA)

	Rainbow trout			Brown trout			Salmon
Environment Agency Area	All Females (thousands)	Mixed Sex (thousands)	Triploid (thousands)	All Females (thousands)	Mixed Sex (thousands)	Triploid (thousands)	Mixed Sex (thousands)
Anglian	20	75	0	0	7	0	0
North East	9,586	26	2,734	142	1,174	103	420
North West	0	1,000	0	0	460	0	670
Midlands	175	10	75	0	145	0	230
Southern	115	9	150	45	104	105	0
South West	9,212	915	2,473	110	475	195	0
Thames	1,425	0	4,245	60	1,407	164	0
Welsh	50	45	0	0	268	0	149
Totals	20,583	2,080	9,677	357	4,040	567	1,469

2.1 million eggs. The recorded production of rainbow trout triploid eggs was almost 9.7 million, which is a slight decrease from the 2001/2002 level of just over 9.8 million. The production of mixed sex eggs has continued to remain stable. Overall rainbow trout egg production appears to have returned to previous levels following the sudden increase in 2001.

The majority of brown trout ova produced were mixed-sex and production totalled just over 4 million ova, a significant increase on last year's figures. Of this total just over one million were sold to other sites. A total of 0.36 million all-female brown trout ova were produced, almost double the 2001 levels – when 0.20 million eggs were produced. Triploid ova production was recorded as 0.57 million – more than doubling the previous year's figure of 0.26 million. This represents an increase of just over 55% in the overall production of brown trout eggs from last year's level and is likely to be a response from the industry to the Environment Agency's stocking policy proposals, in which the use of triploids is desired as the fish are believed to pose no genetic threat to natural trout populations.

Just under one million salmon eggs were produced by commercial salmon rearing sites, which is a significant decrease from 2001 levels. A further 0.65 million eggs were produced for Environment Agency stock enhancement programmes, a decrease of around 20% from last year's levels. In addition, approximately 0.87 million eggs from salmon broodstock obtained from rivers around England and Wales were laid down by commercial hatcheries, in co-operation with the Environment Agency, and reared to produce parr for local stock enhancement schemes. This is a significant increase in activity on behalf of the EA.

The majority of rainbow trout and brown trout ova were produced from farm sites in the North East region.

RAINBOW TROUT EGG IMPORTS IN 2002

Summary of rainbow trout eggs imported into England and Wales by month in 2002

Month	Northern Ireland (thousands)	Isle of Man (thousands)	Denmark (thousands)	South Africa (thousands)	USA (thousands)	Total (thousands)
January		1,810	100			1,910
February		2,900	1,450			4,350
March		2,045	1,625			3,670
April		518	1,925			2,443
May			525			525
June		10	225	1,550		1,785
July		290		5,047	10,700	16,037
August		105		5,590	6,500	12,195
September	200	430		1,490	3,000	5,120
October		1,627		600		2,227
November	150	2,605				2,755
December		1,335	150	100		1,585
Total	350	13,675	6,000	14,377	20,200	54,602
Total %	0.6	25.0	11.0	26.3	37.0	100

Rainbow trout egg imports into England & Wales during 2002 totalled 54.6 million.
This is an increase on the number of eggs imported from the previous year (45.1 million) mainly due to the eggs imported from the USA

ARTICLES

BRITISH TROUT FARMING CONFERENCE, SPARSHOLT, 5-6 SEPTEMBER 2002

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The following report covers the presentations given on the final day of last year's Sparsholt Conference. The report of the first day's proceedings appeared in the January 2003 issue of Trout News.

French/Italian producers

France and Italy are the two leading aquaculture-producing countries in Europe with a total output currently amounting to 52,000 and 66,000 tonnes respectively. Yves Moutounet, a technical support adviser on freshwater aquaculture for Biomar reviewed trout production practices in both countries in answering the question posed in the title of this talk - 'What are they doing to do it right?'

Trout production in both countries is around 45,000 t involving 635 enterprises and 412 sites in France and 180 enterprises and 412 sites in Italy. Prices have fallen over a number of years and to help maintain profit margins continuous efforts are made in product diversification, added value and reduced production costs. Farming practices vary with many small farms in the French Alps using parallel raceways while in Italy raceways are usually in series. Both ground and river water is utilised and most farming operations are highly mechanised. Oxygenation systems are common in both countries and throughout Europe with computer controlled monitoring and alarm facilities. Several systems are employed; those achieving 70% saturation utilise low head systems (which are cheap to operate), U tube or jet platforms. For higher saturation levels up to 130%, high head systems are used but these have much higher running costs.

Most farms have fish elevators (rotating screws) for grading, rotating screens for debris removal and drum filters are increasingly employed for improving inlet and effluent water quality. Grading grates are often used in raceway culture that are slotted in and the fish left to grade themselves overnight.

Pelleted diets of varying size and density are used containing 40% protein and 30% lipid and fed according to fish size. Digestible protein/energy ratios vary from 22 to 16 g/Mj with smaller fish receiving the higher ratio diet. Automatic feeding systems are commonly used for maximising FCR and specific growth rate in conjunction with close monitoring of the stock biomass and water temperature. In France feed is usually injected into water and then piped to the fish while in Italy wheeled vehicles blow feed directly into the raceways. Vaccination is increasingly employed to reduce antibiotic usage, initially by immersion in young fish followed by a booster a few months later by injection or oral routes.

In France 80% of production goes for direct table consumption, 12% for sport fishing and 8% for restocking. Portion size production has dropped from 65% in 1991 to 16% in 1998 in favour of large fish for filleting. Trout fillets now contribute 42% of the market. Processing plants take 60% of the production and 25% is smoked.

In France there is a legal obligation for all trout farms to join ICAP – Interprofessional Committee for Aquaculture Products, which was founded in 1997 and involves producers, processors and feed manufacturers. The role of ICAP is to improve and facilitate communications, meet consumer demands, improve product quality, respect the environment, promote production and represent farms at national, European and international levels. Funding for this is derived from subscriptions (55%), a 5% national contribution and 40% from European sources while expenditure is split between advertising (71%), running costs (13%), research (10%) and quality control (6%). Another professional organization, FAN – French Association for Normalisation - is responsible for product specifications and recommendations on farming practices, processing (slaughtering, gutting, filleting, cooking and freezing) and labelling.

Turning to the future, Mr Moutounet considered the downward trend in trout production would continue in both countries to 43-44,000 t over the next 2/3 years as well as a decline in the number of sites. This, he said, was due to the lack of succession where many farms would close down when the owners died. There would also be more emphasis on added value products and more group processing.

Waste disposal

A topical issue and one that took up much of the discussion at the BTA's AGM, held this year at the conference, concerned waste disposal. Barney Kay, Meat Industry Adviser for the NFU in London, outlined the current regulations concerning the disposal of animal by-products followed by a review of new, more stringent EC rules that are due to replace them early in 2003. With the fish industry facing a ban on routine burial of waste he outlined the likely effects of this new legislation on the trout industry, what options are available and the actions currently taking place to provide a practical solution to the problem.

He began by saying he had no experience of the trout industry but did have a wide knowledge of animal waste disposal. The current Animal By-Products Order 1999 (ABPO) defines animal by-products as carcasses, parts of animals (including blood) or products of animal origin not used for human consumption (with the exception of dung and catering waste). The order requires that animal by-products must be consigned to rendering, incineration or other permitted routes such as knackers yard, export as ensiled waste, fish bait or maggot farming, etc. Burial or burning (except in an incinerator) is not permitted unless farm access is difficult or the quantity and distance to the disposal route did not justify transporting it. This legislation, he said, left many grey areas e.g. definition of distance and quantity and 'removal without undue delay'.

He said advice could be sought from a Divisional Veterinary Manager at local Animal Health Divisional Offices. Also for ABPO compliance the Local Authority (Trading Standards) have a good local knowledge, while for environmental controls the Environment Agency in England and Wales or the Scottish Environment Protection Agency (SEPA) in Scotland should be contacted.

Turning to the proposed new legislation, he said, the Draft Animal By-Products Regulation 2000/0259 aims to update the existing legislation into a single legal framework. This had already gone through the co-decision process involving the European Council and European Parliament and the new EU rules (replacing the ABPO) are likely to come into force in Britain in April/May 2003.

Under this regulation three main categories of animal by-products are defined. These are high risk (diseased material), medium risk (fish waste) and low risk (fit for human consumption but does not enter the food chain for commercial reasons). Routine burial or burning is banned except in remote areas (likely to be defined as Highlands and Islands of Scotland) and in cases of disease outbreaks (where transport would pose a risk). Permitted disposal routes under the new regulation include incineration, knackers yard, licensed landfill and rendering. However concerns over the likely cost implications for industry using these routes has lead to the examination of other options. These are:

- Ensilage. This involves the ensiling or composting of fish waste (also mentioned in the Regulation) but it is not yet known if the process is scientifically safe. Once ensiled the waste must be removed from farms in secure containers for temporary storage. The oil generated from this process can no longer be used in animal feeds but can be used for technical purposes. Composting, he said, was used routinely in America.
- Biogas production.
- National Fallen Stock Collection Scheme.

The NFU has lobbied the UK and Brussels to retain on-farm burial but this is an isolated position in Europe and unlikely to be successful. Alternative solutions involve the formation of industrial stakeholder groups or a national collection scheme where waste would be collected from farms at cost.

With the prospect of a ban on open burning and on-farm burial by April/May 2003 he said industry action was now required in:

(a) Setting up a working group with Defra to look at practical solutions for disposing of fish waste.
(b) Ensuring scientific evidence is presented to the Scientific Steering Committee of the EC on safety aspects of the ensiling process.
(c) Lobbying MPs to raise awareness of the potential problem caused by disposing of waste animal by-products.

In discussions after the presentation it was stated that in France waste fish are frozen on the farm and periodically removed under a national collection scheme.

Angler survey

Paul Knight, Director of the Salmon and Trout Association and Chairman of the Association of Stillwater Game Fishery Managers reported on the Environment Agency's Angler Survey carried out in 2001. He first reviewed the main results of the survey, then looked at possible ways of increasing more anglers to the sport and finally provided some thoughts on the future of stocked fisheries.

The survey showed that angling was in a healthy state in which a significant proportion of the UK angling population wished to learn to fish. The main statistics were 3.9 million people went fresh-water fishing in the last 2 years or 9% of the population over 12 years old. A further 3.5 million showed interest in learning to fish (8% of the population) particularly 35-44 year olds. In England and Wales 17% of the population fished or were interested in fishing. Of the 3.5 million potential anglers 44% had been fishing before. Having someone to go fishing with was mentioned as a factor attracting people back to fishing and taking children was mentioned by 20% of potential new anglers. Within the age group 12-16, 21% had fished in the last 2 years and 15% were interested in learning, making a total of 36% of this teenage group who fished or wanted to try. Attractions for 12-16 year olds included having someone to go with (48%), knowing places to fish (28%) and more fish in rivers and lakes (19%).

The survey had been undertaken on behalf of the Government by one of its own agencies, the EA and therefore carried a high degree of credibility. It indicated that angling was the largest sport in the country with the exception of walking with the potential for 7.4 million participants, more than any other pastime.

He considered next how more people could be attracted to the sport. The Joint Angling Governing Bodies (JAGB) consisting of the National Federation of Anglers (coarse fisheries), the National Federation of Sea Anglers and the Salmon and Trout Association have no remit to regulate the sport. However it is recognised by Sport England and therefore Government supported, receiving grants (currently £125,000) to help jointly develop angling as a sport. The JAGB have developed a 4-year plan containing 36 different strands including policies for juniors, women, ethnic minorities and the disadvantaged. The plan includes a coach licensing scheme to professionalise angling and a JAGB child protection policy designed with full support of the NSPCC and Sport England which was considered essential to keep the sport credible and in line with other sports. A licensed coach with qualifications (technical certificate of confidence) would enable licensing to be carried out at 5 different levels starting from assistant coach (level 1) through to national coach (degree level 5). Licensed coaches would also have a First Aid certificate, be vetted by the Criminal Records Bureau, have attended a Child Protection course and be a member of the Game Anglers Instructors Association.

The Government's interest in angling, he said, stemmed from keeping vulnerable children off the streets. It would require partnerships in providing more facilities, public awareness, tackle hire, commercial fisheries and more professional coaches to instruct. Follow-on facilities would also be required to provide a safe environment and financial investment both from the public and private sectors in fisheries angling clubs and facilities. New anglers would learn how to fish, be knowledgeable of entomology, the anglers place in aquatic conservation and waterside etiquette.

Turning finally to the future he said stocked fisheries provided a perfect environment to learn the sport with plenty of fish to catch and easy and safe access for children. Potential problems were poor fisheries management, limiting factors of disease and parasites and options for wild self-sustaining fisheries may make them expensive. Other factors affecting still water trout fishing in future were the progression of anglers from small trout fisheries to other forms of game fishing, a requirement for better marketing, better facilities, consistent quality of stock fish and value for money.

Fighting fry syndrome

Dr Sandra Adams of the Institute of Aquaculture, Stirling University reviewed the research being carried out in her department on the fight against RTFS, highlighting the difficulties and gaps in the areas of transmission, survival and pathogenicity of the bacterium. She began with some economic data on the ongoing losses to the industry resulting from RTFS. It is now recognised as one of the most important threats to the UK trout industry with annual losses of approximately 1.76 million fry worth £0.5 million and associated indirect losses totalling £l million. This figure is likely to increase with recent observations that RTFS is now becoming a problem in large fish. Antibiotics is the only control method available at present but the bacterium – *Flavobacterium psychrophilum* (Fp) soon develops resistance and treatment does not eliminate the source of infection which may be in brood fish, water or inorganic deposits.

Basic information is still missing on a number of important aspects that will need to be determined before effective control can be achieved. These include the presence and survival of Fp in water, its pathogenicity and ability to attach to eggs, detection using polymerase chain reaction (PCR) to monitor pathogenicity and vaccine development.

Difficulties in culturing Fp in the laboratory have lead to the development of PCR technology for detecting and monitoring the organism in farming situations. The technique has proved to be ultra-sensitive enabling detection of as few as 10 bacterial cells per 50 ml of water. There are disadvantages, however, in that careful controls are required and differentiation between dead and live bacteria is not possible which is important in transmission studies. Inclusion of enrichment methods to improve the culture conditions has proved useful, she said.

Tests carried out on trout farms using PCR have shown Fp is present in outlet but not inlet water, in brood fish where it may act as a reservoir of infection and in, or on, eggs precisely which is uncertain at present.

Research on survival of Fp outside the fish has been carried out by studying the bacterium in water. The bacterial cell changes shape when in water and under starvation conditions and remains capable of surviving up to 9 months and possibly longer in stream water. Starved cells are difficult to detect using PCR due, it is thought, to degradation of the DNA. Studies on the ability of Fp to attach to trout eggs have shown that cells from older cultures adhere much better to eggs. Aged cultures are also more hydrophobic than those from recently cultured cells.

Vaccine studies have identified 5 serotypes that are all slightly different but a standardised challenge model has yet to be developed. Progress has been made on bovine free vaccine preparations that gave high antibody responses in fish but protection from RTFS has not, so far, been demonstrated.

Turning to the future Dr Adams said the key was to reduce the reservoir of infection by producing RTFS free brood stock and eggs. This should be achievable with the high sensitivity of PCR technology. Changes in farm and hatchery layout may also be required to ensure brood stock are quarantined and eggs kept separate. Vaccines will also assist to reduce the reservoir of infection in combination with regular screening, good husbandry and antibiotic treatment. The ultimate goal however was the production of RTFS resistant fish and there was, she said, a good chance of achieving this but only in the long term.

Argulus infections in still water trout fisheries

Nick Taylor from the Institute of Aquaculture, a second year PhD student, gave a brief account of the biology and pathology of the fish louse, *Argulus*, followed by details of a study aimed at identifying risk factors associated with parasite infections in UK still-water trout fisheries.

Argulus species are external crustacean parasites of fish that create problems in aquaculture systems throughout the world. Over 100 fresh water and marine species have been identified three of which (all freshwater) occur in the UK. These are *Argulus foliaceus,* a common species 6 – 8 mm long and found throughout Europe, *Argulus coregonus*, a larger species 8 – 12 mm long occurring in rivers and not associated with the same levels of infection as *A. foliaceus* and *A. japonicus* which is not native and little known and thought to originate from the Far East.

The life cycle of the parasite involves sexual reproduction directly in fish with no intermediate hosts involved. Females carry the eggs on the thorax, which are then laid in rows on surfaces where they hatch and become free-swimming metanauplii. These must attach to fish to survive (obligate parasite) where they undergo 11 developmental stages within 2 weeks. Most fish species may be parasitised but brown trout are particularly susceptible and may depend on fish behaviour. Host finding involves two different strategies – ambush during the day and active searching at night. Factors involved include shadow, visual, tactile and chemical cues (fish mucus). The hooks used to attach the parasite to the fish host cause physical damage and increased mucus production while the pre-oral spine injects digestive enzymes into tissue, which is then sucked up. This not only causes stress to fish but leads to bacterial, fungal and viral secondary infections e.g. spring viraemia.

In still-water trout fisheries there are no practical management strategies or treatments available except draining and liming which is a drastic option. The aim of Mr Taylor's study was to review current perceptions and identify risk factors associated with *Argulus* infections. A quantitative field-based study was initiated in which trout fishery sites were contacted by letter and telephone between July and September 2001. A total of 123 sites were contacted involving 30% of trout fisheries from each region within the UK. A participation rate of 62% was achieved. Each interview was conducted on-site and covered 110 questions including site location, parameters of the lake, management practices and disease history. Fish were also examined for signs of the parasite and water samples collected to determine environmental parameters. A total of 70 sites provided data for further analysis.

The study revealed that *Argulus* was widely distributed in England and Wales, but less common in Scotland. Of the fisheries selected, 42% had a known history of the presence of the parasite and 29% suffered a problem with *Argulus* in 2000. These problems were manifest in fish behaviour involving jumping, shoaling and reduced feeding. There was also a loss in aesthetic appeal of fish such as poor physical condition, thin appearance, scale loss and lethargy.

The interview data identified 20 candidate variables from univariate analysis. The presence of algal blooms, coarse fish, crayfish and turbidity of the water were all identified as significant risk factors. Catch and release data was inversely related to risk while catch and removal was positively related. He thought the presence of algae may stress fish making them more susceptible but did not know why coarse fish was a factor. For every 1-foot increase in water depth *Argulus* problems were reduced. The risk factors now being identified, he said, will be used to develop management strategies in the future.

Total health care

Enteric Redmouth disease (ERM) caused by the bacterium *Yersinia ruckeri* is a major disease affecting rainbow trout culture both in this country and throughout Europe. The final paper of the conference, given by Chris Gould of Aquaculture Vaccines Ltd, described new vaccine strategies for combating the disease that provided total health care throughout the entire production cycle.

The first licensed immersion vaccine against ERM was developed in the early 1980s and since 1984 its use has reduced this disease by over 75%. In spite of this, he said, losses still occur and with pressure on eliminating the use of antibiotics, new methods of effectively protecting fish against ERM have been developed utilising vaccine technology. These involve an initial immersion vaccination of fry at 4-5 g followed by a booster vaccination 4-6 months later given by injection or as an oral in-feed vaccine. Procedures for carrying out these various treatments were then described outlining the advantages and disadvantages of each.

The initial immersion vaccination involves diluting vaccine 1:10 with holding water and ensuring that oxygen is added throughout the treatment period. Small batches of fish are immersed for 30 seconds avoiding overcrowding at all times. The rules governing treatment are:

- Vaccinate at 10°C and above.
- Use only healthy fish of 5 g recommended size.
- Keep stress to a minimum.
- Keep records of vaccination procedure.
- Allow 10 – 14 days prior to any stress challenge such as moving fish

This enables 100 kg fish to be treated per L of vaccine, equivalent to 20,000 fish/L at 5 g. It is less stressful to fish and relatively inexpensive to carry out. It is, however, expensive to carry out on large fish and has only a limited duration of effectiveness. Without vaccination mortalities of 10% can be expected from an ERM outbreak.

A booster vaccination is required between 5-9 months following the initial vaccination. This is necessary to increase the duration and level of protection required to withstand farming stresses (challenge levels) caused, for example, by increased stocking levels and presence of RTFS. Boosting at this stage ensures the fish are totally protected to the end of the production cycle and removes the requirement for antibiotics in the case of disease outbreaks. Many factors determine when booster treatment should be given; these include production objectives for each fish batch and the disease cycle on the farm (i.e. when the main problems occur to ensure best protection).

Booster vaccinations are given by injection or through the feed (oral). Both routes cost about the same and the choice depends on various factors such as fish size (minimum size for injection 20 g), duration of protection required (i.e. the harvest cycle) and water temperature. Oral booster vaccination involves a fixed dose of 0.1 ml vaccine per fish (10,000 fish/L) fed in a double pulse manner 5/8/5 with Ergosan incorporated in the feed as a top-coat at 0.2 – 0.5 % over the first 5 – 10 days. Ergosan acts as an adjuvant by increasing the effectiveness of the vaccine and providing interim protection. It enables cells to perform their role more effectively, particularly phagocyte and lymphocyte cells in blood. Incorporation of Ergosan gives a 20 – 25 day period of effectiveness.

Oral vaccines can be administered at any time, usually determined by the previous immersion vaccination history, production cycle and disease cycle on the farm. The general rules are to treat only healthy fish when water temperatures are above 8ºC. A period of 14 days should be allowed before the vaccine becomes fully effective.

The advantages of the oral route are that no additional labour is involved making it the lowest cost booster method. Also the unit cost is the same, it is less stressful to the fish and timing of treatment is dictated by the fish/environment and not the farm. The disadvantages are the duration of effectiveness is shorter than by injection, feeding competition can lead to unequal intake and the planning required which involves the logistics of getting treated feed produced in large quantities on time. Laboratory results suggest only 15% survival can be expected following an ERM outbreak if no booster vaccine is given while field trials indicate boosted fish required no antibiotic treatment to survive an outbreak.

Injection booster vaccination procedures require fish to be starved before treatment with a fixed dose of 0.1 ml (10,000 fish/L vaccine) injected into the peritoneal cavity (anterior of pelvic fins). Water temperature must be above 6ºC and fish over 20 g in weight and in a healthy condition. Fourteen days are required to build up immunity.

The injection route provides the longest protection at low unit cost and is suitable at lower water temperatures. It is, however, stressful to fish and very labour intensive and therefore expensive and can only be carried out on fish over 20 g in weight. Field trials show mortality of injected fish following an ERM challenge is very low around 0.3% against 15% in controls.

THE SELECTION OF TROUT FOR HIGH AND LOW RESPONSIVENESS TO STRESS: PROGRESS AND PROSPECTS

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Introduction

In 1995 the EC commissioned a project (*CT95 - 0152, Selective Breeding for Stress Tolerance in Aquacultured Fish*) involving a consortium of research labs in four European countries, to investigate the feasibility of selectively breeding farmed fish (rainbow trout and sea bream) in order to minimise their responsiveness to common aquaculture stressors. The overall aim of the project was to improve performance by reducing the adverse effects of stress on growth, reproductive effort, and disease resistance. The purpose of this article is to summarise the progress made during that project and how this has led to new lines of research, both applied and fundamental.

Selection of trout for low and high stress responsiveness was targeted on a single index – the level of the hormone cortisol in the blood of the fish after exposure to a standardised stressor. Cortisol is a key element of the stress response and is also directly involved in many of the adverse effects of stress. Selection of individuals was accomplished using a well-established procedure in which the fish were transferred to a spatially restricted environment, constituting a confinement stressor, and after a set period of time a blood sample was collected for analysis. The non-harmful nature of the stressor allowed repeat testing of individual fish and thus the identification of individuals that displayed either consistently high or consistently low responsiveness to the stressor. These were used to generate offspring, using either high responding (HR) parents or low responding (LR) parents. Testing of the progeny revealed that they had inherited the traits on which their parents were selected indicating that in addition to being a reasonably stable individual trait, the responsiveness of trout to a stressor has a moderately high degree of heritability and would be susceptible to manipulation by selection.

Previous findings

The findings of this project have been summarised previously in *Trout News* (Pottinger, 1997, 1998, 2001) and in a series of papers published in research journals (Fevolden *et al*., 1999, 2002, 2003; Pottinger and Carrick 1999a, 1999b, 2000, 2001a, 2001b; Røed, *et al*., 2002; Rotllant *et al*., 2002; Tort *et al*., 2001; Trenzado *et al*., 2003). Overall, the findings were broadly encouraging. It was possible to produce quite significant alterations in the level of responsiveness to stressors exhibited by trout. Selection did not immediately result in markedly enhanced performance, but nor was performance attenuated in comparison to unselected fish. Arguably, the long-term benefits of rearing low-responding fish might only become apparent in a ‘stress-rich’ environment and there are currently insufficient data to allow a firm conclusion to be reached regarding the desirability of adopting low-stress responsive fish in commercial culture systems. The process of selection itself could be quite costly if carried out using the model established during the EC-funded studies.

Current research

Applied and fundamental

Despite the equivocal nature of the conclusions reached during the project, sufficient evidence of differences in growth and immunocompetence in the selected fish were obtained to stimulate continued investigation of the two lines. These include a study on the genes coding for key enzymes in the cortisol synthetic pathway (with Benoit Auperin at INRA), a detailed examination of the differences in intermediary metabolism in the two lines during stress (with Cristina Trenzado at Granada University) and recent experiments investigating the immunocompetence of the two lines (with Myriam Algoet at CEFAS).

Marker-assisted selection using genomics

Furthermore, the practical application of selective breeding for stress tolerance is being addressed in another EC project, STRESSGENES (*Q5RS-2001-02211; A Functional Genomic Approach To Measuring Stress In Fish Aquaculture*). The lines of HR and LR trout developed by CEH play an important part in this project. The study, coordinated by Patrick Prunet at INRA, and with partners in the UK, France, Ireland, and Sweden, is using microarray technology to examine the pattern of gene expression in a variety of tissues in trout exposed to a range of different stressors (confinement, hypoxia, temperature, salinity, bacterial). The aim is to construct microarrays containing all the genes in each major tissue that are either up-regulated or down-regulated during stress. These will then be used to investigate the expression profiles of genes associated with the stress response in fish displaying divergent responsiveness to selected stressors. The intention is to identify particular gene markers for desirable traits such as stress tolerance, and thus facilitate rapid and effective selection of families exhibiting the desired traits. It is to be hoped that this approach will make selection a more effective and accurate process, relying on the direct selection of a desirable genotype, rather than indirect selection via the identification of phenotypic traits.

Behavioural differences
In addition to the more practically orientated research described above, further work is ongoing to investigate the significance of one of the most interesting findings of the original project. This was the unexpected observation that quite profound differences in behaviour were exhibited by the two selected lines of fish.

The LR fish were found to be more aggressive and competitive than the HR fish. This difference was first noted when it was observed that the two lines grew at a similar rate when reared separately but the LR fish grew better than the HR fish when reared together. A series of behavioural tests using the F2 generation revealed that the LR fish were more aggressive and competitive than the HR fish, to a very high degree (see Trout News, 31, 21-24).

These findings mean that in addition to providing a way of evaluating the practical benefits in commercial terms of selective breeding for reduced responsiveness to stress, the two selected lines of fish provide an ideal experimental model for the investigation of the links between the endocrine system, brain and behaviour in fish.

In a territorial animal such as the trout the potential fitness benefits that are conferred by a genetically-determined competitive advantage are clear. However, they may be offset by opposing behavioural or physiological costs, such as a reduced responsiveness to predation risk or increased metabolic demands. We suspect that the traits exemplified by the two lines represent two different strategies of ‘coping’ with stress, akin to the ‘active’ and ‘passive’ stereotypes identified for mammals (including humans) and both may offer advantages, depending on the type and context of the challenge faced by the fish.

Preliminary studies have demonstrated that, as well as exhibiting differences in aggression, LR fish adapt more quickly to a novel environment, and display a lower level of locomotor activity in response to a territorial intruder than is the case for HR fish. In addition, LR fish appear to retain a learned response longer than HR fish. Whether these differences are derived from a fundamental difference between the lines in brain function, or whether they reflect direct effects of a different stress-induced level of cortisol is something that is being investigated. One particularly promising area of study is the serotonergic system in the brain, that is responsible for control and integration of behavioural and physiological stress responses in both mammals and fish (Øverli *et al*., 2001, 2002).

A programme of collaborative study involving CEH, Glasgow University and the University of Uppsala has been initiated. These studies are at an early stage and are designed to address three main questions: (1) what is the extent to which stress responsiveness is directly linked to behavioural traits?; (2) what is the mechanistic link between stress responsiveness and behaviour; and (3) what are the possible costs of low stress responsiveness?

Conclusion

Although encouraging, the results of the 1995-1999 EC-funded investigation into the feasibility of manipulating the stress responsiveness of aquacultured fish by selective breeding were inconclusive. However, the outcomes of that project have resulted in the opening of several promising lines of investigation. In applied terms, the use of microarray technology to facilitate a selection process that employs a genomic, rather than a phenotypic, marker offers scope for a much more effective targeting of desirable traits and consequently the rapid identification of lines or strains that possess traits of commercial value. As well as playing a pivotal role in that study, the HR and LR lines have also provided a useful experimental tool for investigating some questions that are of fundamental importance to understanding the strategies employed by populations of fish to cope with adverse alterations in their environment. The results of these investigations will also have some applied relevance – if selection on stress responsiveness is to be employed alone or as part of a multi-trait selection process it will be important to understand the behavioural repertoires that will be co-selected, and the implications of those behavioural traits for both production and welfare.

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REPORT ON DEFRA FISH WELFARE WORKSHOP, 28 OCTOBER 2002, LONDON

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Defra’s Veterinary Research Division (formerly the Science Directorate) organised a Workshop on Farmed Fish Welfare to review recent research on fish welfare and to provide a forum to discuss present and future issues - with a view to defining Defra’s objectives in terms of policy and scientific research. There were 48 attendees representing a variety of trade organisations (BTA, Scottish Quality Salmon, FEAP, British Marine Fin-fish Association, Animal Air Transportation Association), animal welfare groups (FAWC, Humane Slaughter Association, RSPCA, CIWF), fish vets, government research labs, universities, funding bodies and Defra.

Nick Coulson (Defra) opened the meeting. A key Defra objective is *to ensure high standards of animal health and welfare.* The Department’s responsibilities include the welfare of fish on-farm, during transport and at slaughter. Defra’s research programme provides scientific evidence on which to base animal welfare policies, strategy and negotiations with the EU, the Council of Europe and other fora. The general policy drivers behind the farmed fish R&D programme include:

- A desire to improve the welfare of fish in existing production systems;
- The development, where necessary, of alternatives to existing systems; and
- The determination and refinement of methods used to measure animal welfare in order to ensure that change will bring about overall welfare improvement.

The research programme is also guided by:

- Advice and recommendations from the Farm Animal Welfare Council;
- The development of recommendations in the Council of Europe;
- Consideration of external reports; and
- The emergence and development of new production systems.

Tim Ellis (CEFAS) talked on the subject of ‘**Cortisol as a fish welfare indicator**’. Cortisol is the classic stress hormone, secreted into the blood to help fish cope with environmental stressors. However, when levels remain elevated for extended periods, cortisol can have detrimental effects on growth, reproductive function, immunity and survival. A variety of common farming practices such as handling, confinement, transportation, grading and disease treatments have been shown to raise blood cortisol levels for a few hours, indicating that they are stressful to the fish. Potential chronic stressors that have been shown to elevate cortisol levels for longer periods include poor water quality, noise, food withdrawal, disease and aggressive social interactions. The use of cortisol as a stress indictor is complicated by the fact that baseline levels fluctuate with various factors (e.g. temperature, fish size and maturity, tank colour, gender and strain), and there have been suggestions that elevated levels may not continue indefinitely under conditions of prolonged chronic stress. The talk then went on to describe the development and validation of a new non-invasive means of assessing stress level by measuring cortisol released into the water as an alternative to traditional blood sampling. The technique had been applied on an experimental scale with results indicating that cortisol levels do not increase with increasing density, thereby suggesting that rainbow trout do not suffer from crowding stress.

Following the presentation questions were asked as to the fact that there is controversy in other animal species over the application of cortisol level as a true indicator of stress. This was debated and it was indicated that other factors, such as growth rate and food conversion ratio, would be used in addition to the level of cortisol to determine whether a fish was experiencing stress. The results from this project tended to indicate that stocking density *per se* might not adversely affect welfare. This issue was discussed and the point clarified; if a producer were to stock fish at high densities the water quality would have to be maintained at high standards. It was added that this would not take into account the behavioural needs of the fish since space at high densities would be reduced.

Mark Davies (British Trout Association) gave a presentation on '**Management practices in trout farming, with regard to welfare - water quality, food provisioning and stocking density**'. The BTA Code of Practice states "trout farmers should recognise that by engaging in the act of fish farming they have a duty of care for the welfare of their stock from egg to harvest". This is encapsulated in the phrase 'stewardship', defined as ownership with responsibility. The three main areas where trout farmers can influence the well-being of their stock are water quality, food provisioning and stocking density. Water quality is a complex matrix of inter-related parameters. Farmers must ensure that appropriate flow rates are maintained, providing adequate oxygen supplies and facilitating removal of products of metabolism. Environmental conditions, which may influence water quality, must be anticipated and necessary action taken. These actions may be further complicated as both the fish and the aquatic medium are profoundly affected by the environment. Food provisioning relates to the quality of feed, its distribution and the daily feeding rate and should optimise nutrition and minimise aggression and the amount of waste products. A variety of systems are employed to deliver feed, and it is essential that methods used are capable of delivering the daily ration in a manner that allows all fish access to adequate feed while preventing wastage. Recognition should also be taken of the crepuscular nature of trout and feeding regimes tailored accordingly. Fasting regimes, best expressed in degree-days are an essential management technique, but should be kept to a minimum. Trout must be stocked at densities appropriate to their size, water temperature and flow, available oxygen, stage in production cycle and type of fish holding unit in order to minimise the risk of poor water quality, physical damage, stress and disease. Given the number of influential variables, the setting of absolute levels must be treated with caution. Appropriate stocking densities are managed on a farm-by-farm basis by maintaining water quality parameters at levels that are thought to be necessary for the maintenance of welfare of the fish. By being aware of all factors likely to influence welfare, the responsibility that rests with the farmer can be satisfactorily discharged. Many of these factors are suitably encapsulated in the BTA Code of Practice, the FEAP Code of Conduct and the QTUK Farm Standards.

Discussion following the talk highlighted the fact that stocking density effects are intrinsically linked with water quality parameters such as the concentrations of dissolved oxygen, carbon dioxide, ammonia and particulate matter. Queries arose as to whether water quality was a predicable indicator of good husbandry. It was felt that there is a need to establish acceptable levels of dissolved oxygen, carbon dioxide and ammonia in the water column and in fact appropriate levels of these parameters have been discussed during Council of Europe (CoE) deliberations. Questions arose about the appropriateness and completeness of EU regulations. It was felt that the CoE document was a pragmatic document that aimed to take account of fish farming practice. The subject of fin erosion was aired, which was thought to be primarily due to physical damage with bacterial infection as a secondary factor. Fasting periods were then discussed. FAWC have recommended that trout undergo a maximum 48 hour fasting period; the period being influenced by the temperature. When producing fish there is a need to consider the stress the fish are exposed to as well as both contamination by gut contents and the quality of the product. Industry's aim is to expose fish to the shortest period of fasting possible and gut evacuation is not complete following a 48 hour fast at low temperatures. This was thought to be an area that required further research. On-farm welfare assessment was addressed. Farmers assess the fishes overall state, and veterinary inspectors undertake a similar practice, and if welfare appears to be compromised further investigation is undertaken.

Lynne Sneddon (Roslin Institute/University of Liverpool) gave a talk entitled '**Assessment of pain in fish**'. The ability to detect and react to potentially painful, injurious stimuli is crucial to survival and has been demonstrated in mammals, birds and amphibians but not in fish. Therefore an integrated approach to assess nociception and possible pain perception in rainbow trout was initiated. Neuro-anatomical analysis of the trout head confirmed the presence of the same types of nerve fibres that convey pain information in higher vertebrates. Electrophysiological recordings demonstrated that receptors on the trout head responded to noxious stimuli and that these receptors had similar physiological properties to mammalian nociceptors. These findings prove that trout are capable of nociception - the detection and reflex response to a noxious stimulus. Following injection of short-term noxious chemicals into the lips of trout, gill beat rate showed a marked increase. Prolonged behavioural responses including the performance of anomalous pain-coping behaviours were observed. Injected fish also did not show an appropriate fear response to a fear-causing stimulus. Fish did not feed until the physiological and behavioural responses had subsided. These changes in behaviour were not merely reflexive and suggest higher processing is involved, and therefore that the rainbow trout is potentially capable of pain perception.

Debate followed as to whether fish have cold receptors and whether exposure to low temperatures was a welfare issue. Different opinions were aired. It was suggested that if fish had cold receptors then exposure to low temperatures may be a welfare issue but this conclusion would require additional research. Results also indicate that carbon dioxide - used for the slaughter of fish - may be a noxious stimulus. Under current Scottish Quality Salmon (SQS) Codes of Practice, CO_2 slaughter is disallowed, although it is included in the CoE recommendations.

Jeff Lines (Silsoe Research Institute) reviewed the work within the project '**Automated humane slaughter of trout**', which was carried out in close collaboration with the University of Bristol and the Humane Slaughter Association (HSA). A review and initial trials assessed the welfare and quality issues of various fish slaughter methods. Electric stunning in water was identified as the method most suitable for humane slaughter of trout, but further research was initiated to overcome carcass quality issues. Experimental work identified the parameters of the electric field (strength, frequency and duration) that resulted in permanent insensibility, produced few haemorrhages, and were consistent with commercial operational requirements. A 60 sec exposure to a 1000 Hz sinusoidal electric field of strength 2.5 v /cm rms was found to permanently stun portion sized rainbow trout. A demonstration machine capable of working at around 2 tonnes per hour was then built and tested. It results in a high standard of fish welfare at slaughter, provides a relatively safe working environment and fits into current harvest practises. It has been found to produce the same low level of haemorrhaging as the traditional slaughter method, a longer pre-rigor period during which the fish can be processed, and lower levels of slime and surface damage on the fish. Production humane slaughter units can be designed and built based on the findings of this project and on the design of the demonstration machine. Although implementing humane slaughter will never be as cheap as traditional techniques, improvements in the quality of the carcasses may offset some of the implementation costs. The British trout industry is working towards the widespread adoption of this technology, and the HSA is actively supporting the technology transfer.

During the discussion, it was asked whether water hardness affected the systems efficacy. During the project little differences in effectiveness of the system had been encountered in areas with different water conductivity levels. The influence of stun time on carcass quality was deliberated on. The current project examined the effect of a maximum 60 sec stun time on carcass quality. Generally as stunning time increases, lactic acid in the muscles increases and that can reduce the time to rigour. It was debated as to whether this was a negative response especially as carcasses that go into rigour quickly would also come out of rigour quickly. A question arose as to whether the body of the fish would be damaged as a result of the rotating drum design. Originally this had proved problematic, but additional input brushes at the entrances to the drum had alleviated the problem. The project's aim of establishing the electrical parameters required to slaughter fish had been accomplished and the future of the system was dependent on uptake by industry.

Eric Hudson (CEFAS Weymouth) spoke on '**Fish Disease and Welfare**'. He highlighted the importance of the interactions between pathogens, environmental conditions, stress, disease and welfare. Fish disease is therefore intrinsically linked to the control of the environment and also the pathogens. In the 1970s and 1980s the increased intensification and growth of the aquaculture industry saw a rise in the incidence of disease, e.g. whirling disease caused by a protozoan parasite. A simple management change from mud (the habitat of the intermediate host) to concrete ponds was sufficient to control the disease. Disease occurrence may be alleviated in a number of ways including the control of movement of fish introductions, the routine inspection of fish kills and diseased fish, and habitat management and conservation. Fish diseases tend to be species specific. A number of examples of fish diseases were presented for which there were no easy treatments, e.g. trout BKD. It was also suggested that the costs associated with receiving veterinary medicine approval and licensing needs to be assessed. Further research is required on the potential welfare consequences of those systems that re-circulate their water supply especially as their use is on the increase.

The subsequent discussion centred on the fact that there are limited numbers of licensed products currently available for the treatment of fish. Presently amoxicillin is being used but this requires a lengthy withdrawal period before the fish can go to market. It was stated that under the current cascade, the industry could use licensed products that are presently being used for other animals. BKD and sleeping disease were used as examples of diseases where there are no effective treatments currently available. It was suggested that the problem lay with the cost of the licensing procedure and the fact that each product needs a separate licence for each EU State.

In a session on fish transportation, **Paul West (Tropical Marine Centre Ltd)** described the transportation of tropical ornamental fish in the talk ‘**Reef to Retail**’. TMC works closely with 39 livestock suppliers in 26 countries to ensure the most rigorous welfare and environmental standards are met. Everything is done to ensure that livestock is net caught and held near to the catching area in well designed and carefully managed holding facilities. TMC imports more than 500,000 animals represented by over 1200 species of fish and invertebrates annually. Upon arrival at TMC’s facilities the fish are unpacked in a separate facility equipped with red lights. The fish are carefully acclimatised over many hours and are then placed in individual aquariums or compartments to rest and be introduced to a variety of enriched frozen foods. When selected for sale, all livestock are individually screened by experienced staff and packed in double wall polythene bags, enriched with oxygen, and then sealed and placed in polystyrene boxes for dispatch to retailers.

Following the talk, it was asked whether current IATA livestock regulations were adequate to ensure the welfare of fish arriving in the UK and if TMC received any feedback from carriers regarding this matter. Fish importers are responsible for the fish’s welfare but the arrivals departments at the airport also share some of this responsibility and Border Inspection Posts (BIP) are in place to ensure that welfare standards are met. The debate progressed to the topic of what additional legislation is required in relation to fish imports and also with regard to fish movements within the UK. Currently there are a number of pieces of legislation that relate to the importation of tropical fish but a real issue is the length of time it takes to pass fish through the BIP. This can add up to 6 hours onto the overall transportation time and during this time TMC cannot gain access to fish to monitor them. Additionally there is no current legislation that covers disease control of tropical fish imports and this needs to be addressed.

John Beardmore (Fishgen Ltd/University of Wales Swansea) concluded the formal presentations by speaking on ‘**Fish breeding and welfare**’. The systematic utilisation of genetics in farmed aquatic species lags well behind that applied, with great success, to terrestrial plant and animal species. Nevertheless, there is now available a large portfolio of techniques which, either singly or combined, can be used for genetic improvement of stocks. The primary goals of breeding programmes tend to focus on performance characteristics like growth rate and disease resistance though in some species end-user driven characteristics like taste and texture are being considered. Welfare considerations do not appear to be prominent. The production of genetically improved stocks is not, in principle, inconsistent with high standards of welfare. There are sound reasons for arguing that appropriate application of genetic technology can be expected to contribute to increasing the well-being of farmed fish in some, but not all, respects.

The discussion opened with a comment on how geneticists generally justify breeding programmes and genetic manipulation by the production advantages that these give the farmer. The example of the dairy cow, which has been selected for increased milk yield, was used. In this example the cow does produce greater volumes of milk but a consequence of this has been reduced longevity for the cow. Thus, although there are short-term gains for the farmer overall, there is a minimal benefit. The general consensus was to agree with this sentiment. It was stated that there are benefits to be had from breeding programmes but that each species and market must be looked at individually. In contrast concern was raised about this type of technology, e.g. breeding fish for disease resistance. It was argued that this would not be necessary if it weren’t for the fact that animals were farmed intensively. The debate then moved on towards ‘fitting the fish to its environment’. Most EU countries have examined the natural behavioural repertoire of farmed animals. Subsequently they have looked at the environment and husbandry system in an attempt to allow animals to perform the full range of behaviours they express. It now appears that genetics may be able to change behavioural expression so ‘fitting’ the fish to its environment. It was felt that in order to maintain an animal’s welfare it should be able to ‘fit’ its environment. Views were expressed that it is good to be cautious about genetic modification and transgenics. There must however, be some level of genetic management in aquaculture as there is a need to maintain genetic diversity within the farmed fish population.

A general discussion then followed, dominated by three areas: methods of welfare assessment, methods of slaughter and stocking density. Discussions throughout the day highlighted the fact that indices of welfare are difficult to measure and interpret. Consequently, there is a need for a number of industry-wide agreed indicators to measure fish welfare. The Fisheries Society of the British Isles has drafted a briefing document that includes a list of possible indicators of welfare. The difficulty with these potential indices is the lack of sufficient information available on the sample sizes of fish required to validate the measures. It was stated that any indices derived on an experimental level required scaling up to on-farm trials and it was good to see that the Defra stocking density project intended to do this. It was suggested that if growth, food conversion ratios and mortality levels were all acceptable then you might infer that the animal's welfare is not being compromised. This was debated until the consensus of opinion was that it would be beneficial to try to marry production and welfare assessments giving a practical method to assess welfare.

The slaughter paper presented at the workshop was welcomed particularly as current European legislation only deals with emergency slaughter. Counter to this it was stated that in the current WASK regulations fish are covered under the general provision, regulation 4 so that, "No person engaged in the movement, lairaging, restraint, stunning, slaughter or killing of animals shall – (a) cause any avoidable excitement, pain or suffering to any animal; or (b) permit any animal to sustain any avoidable excitement, pain or suffering."

Discussion progressed to the issue of legislating for a maximum stocking density particularly to aid the control and emergence of disease. The general feeling was that if water quality was maintained farmers could stock at higher densities. It was suggested that perhaps measures could be taken to allow farms that maintain water quality to stock at higher stocking densities, which is comparable to the broiler stocking density system used in Sweden. The limits for water quality measures e.g. dissolved oxygen, particulate matter, would need to be established, and these levels would need to be both species and system specific. The point was discussed at length and concern was raised about the repercussions of not setting a maximum density figure. It was also pointed out that observations of schooling species show that fish concentrate together so actual local density is far higher than average densities on which legislation would be based.

Post-meeting note

Following the workshop, Defra's Animal Health and Welfare Directorate has recently announced that it has made funds available for two applied specific research projects:

R4: A study to define water quality parameters to optimise welfare for trout.

R5: A study to determine the causes of fin erosion in trout and its impact on fish welfare.

Further information on the call for research propopsals is available at http://www.defra.gov.uk/science/RRD

FISH HEALTH CONTROLS: THE ACTIVITIES OF THE FISH HEALTH INSPECTORATE IN ENGLAND AND WALES 2002

Alasdair Scott, CEFAS Weymouth Laboratory, Barrack Road, The Nothe, Weymouth, Dorset DT4 8UB

Introduction

The work of the Fish Health Inspectorate at CEFAS Weymouth has been documented annually in *Trout News* since 1996, to give the industry feedback on how the individual farm inspections we carry out on their sites relates to the overall fish health regime in England and Wales

This report aims to provide an update of the Inspectorate's work during 2002, showing how it performed with respect to the targets set in each area of its work and outlining the current status of notifiable diseases of fish in England and Wales.

This report does not include details of the Inspectorate's shellfish programme, which is reported annually in Shellfish News.

Inspection programmes

Details of the number of inspections carried out in each area of the Inspectorate's work are shown in Table 1.

The fish farm inspection programmes returned to their normal format in 2002, following the major disruptions due to the Foot and Mouth Disease outbreak in 2001. All registered salmonid farms were visited in the spring, with all sites holding broodstock, or operating hatcheries, receiving a second inspection during the autumn. Samples were taken from approximately half of these farms as part of the routine fish health monitoring programme, which ensured that the necessary work in support of the maintenance of our Approved Zone status was completed to the required standard.

In addition to this routine monitoring, samples were taken on farm sites where inspectors observed disease signs in fish, or where farmers reported disease problems to us. Only 20 such samples for notifiable diseases were taken in 2002 continuing the trend of low numbers seen in the previous two years. This suggests that they may reflect a general improvement in fish health on trout farms in recent years. Fortunately none of these investigations confirmed the presence of any notifiable disease.

Table 1. Number of tasks, by category, undertaken by the Fish Health Inspectorate in 2002

	Site type		
	Salmonid	Coarse	Total
Farm inspections (no samples)	258	169	427
Routine sampling and inspection	147	0	147
Inspection and sampling on suspicion	2	2	4
Notifiable disease re-tests and contact tests	5	12	17
Reported disease outbreaks & mortality investigations	18	150	168
Import checks: Sampling	14	60	74
Inspection/physical checks	17	25	42
Export certification	5	103	108
Farm registration visits	5	14	19
Site disinfection visits	1	4	5
Wild fish monitoring	2	0	2
Other visits/inspections	28	120	148
		Total	1,161

The inspectorate also collected samples for testing for the presence of veterinary medicines, unauthorised or banned substances from 105 salmonid farms in 2002, with follow up investigations only being required on three occasions, in relation to detected residues of malachite green or leucomalachite green.

The inspection programme for coarse fish sites during 2002 involved a single visit to each farm site, to look for evidence of mortalities and to check movement, mortality and medicine records. In addition the programme of import checks on consignments of SVC susceptible species coming from non-EU countries was maintained. As a result a total of 85 consignments were inspected, with 60 sampled, from all of the major countries supplying such fish. All tests proved negative for SVC.

The Inspectorate also investigated 105 mortality events in coarse fishery waters and a further 46 in sites holding coldwater ornamental fish during the year. Five sites tested positive for SVC, two were disinfected and the others were Designated for this disease. A significant increase was noted in ornamental carp mortalities where Koi Herpes Virus (KHV) was suspected to be a cause. The number of coarse fish mortality investigations was lower than in previous years, but it is thought that this reflected a disruption to the reporting and sampling procedures arising from the major re-organisation of the EA fishery function during the year, rather than any real fall in mortality events.

The status of notifiable diseases in England and Wales

VHS and **IHN**. All registered farm sites continue to test negative for these List II viral diseases, as did all samples of fish from UK sources. None of the reported disease problems or suspicion samples was connected to a suspicion of either of these diseases.

BKD. There were no new cases of BKD identified in 2002, and only four sites remained designated for the disease at the end of the year. Three of the sites are no longer operational as farms, though one may be re-developed as a fishery. The fourth site has undertaken two of the necessary three years of negative testing for the disease, and it is hope that controls may be lifted in 2003.

It appears that one clear benefit of the EU monitoring programme on trout farms has been the control of a substantial outbreak of clinical BKD discovered during the first year of that programme in 1993. Half of the initial discoveries of BKD on farms in 1993 and 1994 resulted from inspectors observing clinical signs, during site inspections or while sampling for viruses, and taking 10 fish samples on suspicion. Such inspections have continued in the same manner each year, and in the last five years have given rise to only 19 samples, and only two confirmed cases of BKD.

IPN. All salmon farms continue to be tested annually for IPN, and in 2001 all sites tested negative in England and Wales. There are no farms subject to movement restrictions for this disease.

Gyrodactylosis. All salmonid samples from farms or wild environments were screened for *G. salaris* and none were found positive. As in previous years a number of other *Gyrodactylus* species were found, but never at levels likely to cause health problems for the fish.

SVC. Re-testing for SVC took place on three infected sites in 2002, all tested negative for the disease.

Investigations into mortalities of susceptible species resulted in the discovery of two separate outbreaks of SVC, the first of which involved three fishery sites, supplied, we believe, with illegally imported fish from Europe. The second outbreak involving a garden centre and a linked aquarist pond revealed the presence of a strain of SVC closely related to the Asian strain isolated from goldfish imports in 1998. It is thought that this represented a second introduction of SVC from areas reportedly free of the disease.

This finding has prompted further refinements to the import checks programme such that individual export sources will be targeted for screening in 2003 rather than simply countries of origin.

At the end of 2002 there were six sites Designated for SVC in England and Wales

Emergent Diseases

Sleeping disease. One notable disease problem during 2002 was the appearance for the first time of sleeping disease, at a table trout farm in southern England. This is a viral disease caused by an atypical alphavirus related to, if not the same as, that causing pancreas disease in salmon. Fortunately this outbreak appears to have been controlled on this farm, and there has been no recurrence of the problem as this report goes to press. The appearance of this disease highlighted both the need for farmers to be vigilant about site bio-security, and the need for the Inspectorate and colleagues in CEFAS to be proactive in assessing the potential risks from new and emergent diseases.

Lactococcus garvieae. There has been no indication that lactococcosis has caused any further problems in the fishery water where the country's first outbreak was recorded following the cessation of farming at this location in 2001. The inspectorate maintain a watching brief for potential outbreaks of this disease both at this and other waters.

Koi Herpesvirus (KHV). A notable development in 2002 was the apparent increase in serious mortalities of koi caused by Koi Herpesvirus (KHV). While part of the increase in reports was inevitably due to an increase in publicity of the disease, there was a clear indication that the disease posed significant problems for the trade in 2002. While the lack of a definitive diagnostic test for asymptomatic or latent carriers of this virus have prevented the Inspectorate from conducting a screening programme on resident or imported koi stocks, the Inspectorate and colleagues in CEFAS have tried to work closely with the industry to investigate practical methods for dealing with this disease threat.

A number of large importers have suggested they will seriously reduce their koi imports in 2003 while others are looking for methods to force the expression of the disease in new stock prior to its release from quarantine. The Inspectorate and colleagues will endeavour to assist the trade where possible and also propose to monitor the potential risk this virus may pose to carp populations in fishery waters.

Import/export trade

As ever, there was a significant demand for licences to import fish from countries outside the EU. A total of 606 licences were issued. This figure was very close to that for 2001, but due to changes in koi and goldfish licensing rules from the USA late in the year following the first isolation of SVC in ornamental carp in the USA in 2002, the numbers are likely to increase in the coming year. Table 2 gives details of the number and type of licences issued and also movement documents issued for fish exports, by fish type.

The major import trade remains that in tropical fish, goldfish and koi carp from outside the EU. Imports within the EU were predominantly salmonid eggs for farming and turbot for direct consumption, as in the previous three years.

The small export trade was again predominantly in ornamental fish to the EU, with few salmonid egg exports.

Illegal imports

The illegal import of coarse fish for introduction to fishery waters remained a significant problem in 2002. During April the Inspectorate intercepted a large illegal consignment of 266 mirror carp, entering the country via the Channel Tunnel. These fish were seized and destroyed. Samples from them confirmed that they were positive for SVC virus, the strain of which suggested that the fish had originated in Eastern Europe though a Belgian farmer had supplied them. The principal importer was successfully prosecuted, and sentenced to nine months in prison, suspended for two years, because of exceptional personal circumstances. His colleague a first time offender was sentenced to 100 hours of community service. The Inspectorate were delighted that the Crown court had confirmed that serious breaches of the import legislation will lead to custodial sentences for offenders. In addition to these sentences the offenders lost stock, which were valued at around £60,000, and had to pay fines of a further £2,000. It is hoped that with the imposition of such penalties by the courts, the temptation to illegally import fish will be greatly reduced.

Table 2. Imports and exports of fish monitored by the Inspectorate in 2002

A.	**Import licences by category for trade from non-EU countries**		
	Tropical species (annual licence)		177
	Koi & goldfish (annual licence)		184
	Specified purpose (Indiviual consignment)		182
	Human consumption		63
		Total	606
B.	**Movement documents for EU trade**		
	Import documents received/checked		
	Salmonid eggs		114
	Turbot (for direct consumption)		116
	SVC susceptible fish		114
	Other fish		163
	Shellfish		11
		Total	518
C.	**Export documents issued**		
	Fish		186
	Shellfish		76
		Total	262

There was a massive increase in support for the Inspectorate's enforcement activities by the carp fishing industry in 2002, principally the result of efforts by the English Carp Heritage Organisation (ECHO) to educate their angling counterparts to the threats posed by illegal imports. In a particularly rewarding case, the Inspectorate acting on information supplied by ECHO were able to foil the theft of carp from a French fishery, by contacting the local Guarde de Peche, who discovered sacked-up carp awaiting transport to England, and were able to release them back to the lake. Several British anglers face action by the French police in respect of this incident. These high profile incidents have resulted in the popular angling press taking up the banner against illegal imports.

The Inspectorate remains keen to receive any information about potentially illegal imports of fish and its HOTLINE number 01305 206681 is available twenty-four hours per day. The Inspectorate also operates an on-call system providing twenty-four hour cover by fish health inspectors. The duty inspector can be reached via the Defra duty office on 0207 2708960.

Summary

The Fish Health Inspectorate completed all of its statutory inspection programmes in 2002, and conducted all necessary investigations into reported fish disease outbreaks. The absence of any significant salmonid diseases demonstrated that we are able to maintain approved zone status for VHS and IHN.

The isolation of SVC from fishery waters and the ornamental fish trade, illustrate our need to refine our import screening programme and maintain maximum effort towards the prevention of illegal fish imports, which pose more than just the threat of SVC.

The Inspectorate is grateful for the co-operation shown by the vast majority of the industry, to provide samples, farm records and other information sought during site visits. We are particularly pleased by the positive feedback we are now receiving on our efforts to combat illegal fish imports.

INFORMATION FILE

IN MEMORY OF PROFESSOR NIALL BROMAGE, 1942 – 2003

Members of the aquaculture industry, and the trout industry in particular, are mourning the passing of friend and colleague, Professor Niall Bromage of the Stirling University's Institute of Aquaculture and Technical Advisor to BTA.

Niall held the trout industry close to his heart and had a great fondness for it. It was where he began his work on fish endocrinology, and one only has to look at the number of PhD theses on the shelves of his office to see how many names are still active in the industry having passed through Niall's expert hands and to see the influence he has had and the people upon whom he has conferred his enthusiasm.

Niall was very serious and passionate about his science and his work. As the British Trout Association's Technical Advisor for the past twelve years, he worked tirelessly on the Association's behalf unlocking substantial funding for research projects, developing our Code of Practice and bringing his enormous expertise and experience to bear on our relatively small industry. He was held in high esteem by all colleagues at Defra both past and present, and his contributions to meetings were always well thought out, reasoned and purposeful; the driest of debates being frequently peppered with Niall's pithy and caustic humour and his point of view argued enthusiastically, driven by his commitment to the cause. Occasionally his passion would be mistaken for bad temper and grumpiness by those who did not know him well; being a perfectionist, he took no prisoners when he saw poor or sloppy thinking. Nevertheless he was deeply loyal to his colleagues, students, friends and to those whose opinion he respected.

His academic achievements are many, with a list of publications to his name running to many dozens of pages and his expertise in reproductive physiology has been applied in many species and locations. At the Institute, he was very kind to his students and took great pleasure in seeing them develop, especially when they stayed within aquaculture as Niall was a great believer in collaborative research and in the practical application of science. The knowledge and expertise which he and his team developed over the years has been instrumental in allowing spawning times to be modified and he was a passionate advocate of the industry having access to year-round supplies of home-produced ova. The successful management of broodstock and improvement in production methods of ova and fry were common themes throughout much of his research.

Photo courtesy of Institute of Aquaculture

He had been almost ever present at the Sparsholt Conference and its predecessor at Two Lakes and he was very proud to have received the Peter Jones Award in 1997 for his outstanding contribution to fish farming – the only time he was ever at a loss for words! Niall is remembered fondly by a huge number of people from both his social and working life. His sense of humour never deserted him, counterbalancing the seriousness with which he undertook his work and play, where his deeply competitive nature still came through loud and clear – as anyone who ever played squash against him will testify.

He was a man who held traditional values very dear and to whom his family was everything. Greatly esteemed by his peers, he will be missed very much by us all. Our thoughts and deepest sympathies go out to his wife Anne and children Sarah and Iain.

Mark Davies,
British Trout Association,
June 2003

THE FISH HEALTH INSPECTORATE AND YOU

STANDARDS OF SERVICE – CITIZENS CHARTER PERFORMANCE RESULTS

Debbie Murphy, CEFAS Weymouth Laboratory, Barrack Road, The Nothe, Weymouth, Dorset DT4 8UB

Introduction

The Fish Health Inspectorate (FHI) aims to provide an efficient, quality service. Our standards of service have always been high and we are constantly looking for ways to improve them. Under the terms of the Citizen's Charter we are required to publish an annual summary of the results of our performance against the standards set. The results are reported in the Defra publications 'Trout News' and 'Shellfish News', which are sent free to all registered fish and shellfish farmers. A copy of the results is sent separately to all fish and shellfish import licence holders and can be found on our web site www.efishbusiness.com . Additional copies of our new Charter can be obtained from the FHI or on the CEFAS web site www.cefas.co.uk .

The FHI has agreed to answer all calls to the licensing and administrative team (01305 206673/4) promptly. Since the publication of our new charter document we have accepted the Defra standard within 10 rings (20 second period). This is monitored regularly by logging all calls received on a chosen day. We fully met this standard.

An increasing number of callers are directed to our web site dedicated to the movement and keeping of fish – www.efishbusiness.com to fulfil their requirements e.g. to obtain forms, students researching projects.

The following report shows the performance achieved against our target of 100%, for the period 1st April 2002 to 31st March 2003.

	Achieved in 2002-03
Correspondence	
The Inspectorate's target is to reply to all letters, e-mails, faxes and complaints, within 10 working days of receipt.	**98.4%**
Import licence applications	
The Inspectorate has undertaken to issue import licences within 10 working days of receipt.	**99.8%**
Deposit licence applications	
The FHI issue lobster and mollusc deposit licences, these are not currently covered by our Citizen's Charter Statement, but it is currently our aim to issue them within 10 working days.	**100%**
Movement document applications	
The Inspectorate has agreed to respond to all requests for movement documents, provided 5 working days' notice is given.	**100%**
Fish and shellfish farm registrations	
Registration visits The Inspectorate has undertaken to visit all potential farmers within 20 working days of receipt of their application.	**76.2%**
Registration administration The Inspectorate aim to complete the administrative action within a further 10 days from the date of the visit.	**69.1%**

Notifiable diseases

Respond immediately to a notification of suspicion of infectious salmon anaemia (ISA), infectious haematopoietic necrosis (IHN), viral haemorrhagic septicaemia (VHS), gyrodactylosis caused by *G. salaris*, bonamiosis, marteiliosis, haplosporidiosis, iridovirosis, mikrocytosis and perkinsosis.	**100%**
Respond to other notifiable diseases within 2 working days.	**100%**

Reporting of test results and visit summaries

The FHI must report all negative test results within 5 working days of the full results becoming available and give a verbal report within 1 working day where a notifiable disease is found. We have agreed to provide a follow up letter within 10 working days to advise the farmers in writing of any points raised during the visit.	**72.8%**

Overall results

The overall compliance rate with our set targets.	**86.2%**

The total amount of correspondence received and recorded by the Inspectorate was 2,213. Our performance fully met or approached our targets in most areas. We will continue to strive to achieve all our standards in 2003/2004.

Areas where compliance was low included farm registration visits, which in practice are arranged for mutually convenient dates for the FHI and the farmer, rather than to a strict deadline.

In 2002 registration administration was hampered by significant staff shortages in the Inspectorate licensing and administration team.

The reporting of test results is often delayed where Inspectors involved in a disease investigation, are conducting other routine inspection duties when the results of that investigation become available. Other inspectors may not then report results on behalf of their colleague, as they are often unaware of the full circumstances of that disease investigation.

Customer care helpline

The purpose of our work is to prevent the introduction and spread of disease into and within England and Wales. This involves implementing European Union Fish Health Directives and administering and enforcing national legislation. In carrying out this work our main aim is to ensure that you receive a high quality, cost effective service so that your compliance costs are kept to a minimum. The best way for us to measure our performance is to receive feedback from people who require our service. To help us achieve this we have set up a Customer Care Helpline on 01305 206673/4 where all complaints will be recorded and, thoroughly and impartially investigated. Our helpline staff can assist the customer to formulate the complaint and will explain in full our complaints procedure. They will also aim to send a reply within 10 working days and to ascertain whether the customer is satisfied with the outcome.

BRITISH TROUT FARMING CONFERENCE, SPARSHOLT 2003

Wednesday 3rd, Thursday 4th and Friday 5th September 2003

PROGRAMME

Wednesday 3rd September

pm	Golf/fishing/clay-pigeon shooting
From 19.00	Skretting BBQ

Thursday 4th September

09.00 – 10.00	Registration
Morning Chair:	Nick Read, Alderley Trout Farm
10.05 – 10.15	**Welcome and Opening Address**: Tim Jackson, Principal, Sparsholt College Hampshire
10.15 – 10.40	**Fisheries, Aquaculture and Sustainability**: Sachi Kaushik, INRA
10.40 – 10.45	**Discussion**
10.45 – 11.10	**Efficiency in trout farming via new farm lay-outs** **- new ways of planning and controlling your trout production**: Anders Andreassen, Biomar A/S
11.10 – 11.15	**Discussion**
11.15 – 11.45	**Coffee**
11.45 – 12.10	**Biofilters**: Bent Højgaard, Danaq Consult
12.10 – 12.15	**Discussion**
12.14 – 12.40	**Selective Breeding**: Brendan McAndrew, University of Stirling and John Woolliams, Roslin
12.40 – 12.45	**Discussion**
12.45 – 14.00	**Lunch**
Afternoon Chair:	Gerard McGrath, Skretting
14.00 – 14.25	**Food Quality: a question of assessment, management and communication**: Reid Hole
14.25 – 14.30	**Discussion**
14.30 – 14.55	**Trout Markets: can stagnation be turned into profitable growth?**: Andrew Cookson, Gira Foods
14.55 – 15.00	**Discussion**
15.00 – 15.45	**Tea**

AGMs	15.30	BTA	
	16.15	QT (UK)	Sainsbury Building ~ classroom
	17.00	BTFRA	

19.00 **Reception**
AVL Schering-Plough

19.30 **Conference Dinner**
After-dinner speaker: Nick Yonge

Friday 5th September

09.00 – 09.45 **Registration and Coffee**

Morning Chair: Shaun Leonard

09.45 – 10.30 **Feeding Strategies**:
Chris Beattie, Skretting

10.30 – 10.35 **Discussion**

10.35 – 11.05 **Coffee**

11.05 – 11.30 **Stocking Density and Trout Welfare: a review of previous studies**:
Tim Ellis, CEFAS

11.30 – 11.35 **Discussion**

11.35 – 12.00 **Too close for comfort? Investigating the links between stocking density and trout welfare**:
Ben North, Institute of Aquaculture, University of Stirling

12.00 – 12.05 **Discussion**

12.05 – 12.30 **Humane Slaughter**:
Jeff Lines, Silsoe Research Institute

12.30 – 12.35 **Discussion**

12.35 – 13.30 **Lunch**

Afternoon Chair: Robert Hughes, Skretting

13.30 – 13.55 **Sleeping Disease: a lesson in biosecurity**:
Alasdair Scott, CEFAS

13.55 – 14.00 **Discussion**

14.00 – 14.25 **RTFS – Experiences from Denmark**:
Niels Henrik Henriksen, Association of Danish Trout Farmers

14.25 – 14.30 **Discussion**

14.30 – 15.00 **Pyceze Update**:
Andrew Grant, Novartis Animal Vaccines Limited

15.00 – 15.05 **Discussion**

15.05 **Tea and Close of Conference**

For further details please contact Angela Ingle, Sparsholt College Hampshire, Winchester, Hampshire SO21 2NF.
Tel: 01962 797461; email: aingle@sparsholt.ac.uk; website: www.sparsholt.ac.uk

NEW BOOKS

1. Biotechnology and Genetics in Fisheries and Aquaculture

A.R. Beaumont & K. Hoare -
School of Ocean Sciences, University of Wales, Menai Bridge, UK

This important book carefully explains the science and application of molecular and genetic techniques to fisheries and aquaculture and what these new technologies have to offer. Contents include a full explanation of genetic variation and its measurement, genetic structure in natural populations, genetics and artificial selection in the hatchery, ploidy manipulation and the use of genetic engineering in aquaculture. *Biotechnology and Genetics in Fisheries and Aquaculture* will be extremely useful as a reference to fish farmers and fisheries scientists and all those working in fisheries and aquaculture management and research.

There are chapters on: 1. What is Genetic Variation?; 2. How can Genetic Variation be Measured?; 3. Genetic Structure in Natural Populations; 4. Genetic Considerations in the Hatchery; 5. Artificial Selection in the Hatchery; 6. Triploids and Beyond: Why Manipulate Ploidy?; 7. Genetic Engineering in Aquaculture.
This illustrated hardback book has 176 pages. You can order a copy at a special 20% discount price of £31.50 from Blackwell Publishing Direct Orders, c/o Marston Book Services on Tel: + 44 (0) 1235 465500, Fax: + 44 (0) 1235 465556, Email: direct.order@marston.co.uk and quote 'Beaumont Trout News Special Offer'.

2. Interactions between Fish and Birds: Implications for Management

Edited by I.G. Cowx -
Director, Hull International Fisheries Institute, UK

The interactions between wild bird populations (many protected by law) and fish, particularly those under commercial culture or part of a fishery is subject of much controversy. Ecological, environmental and conservation pressures run alongside commercial pressures on exploited fish populations.
This exciting book draws together contributions from all over the world to provide a fascinating insight into many case studies and conflicts in managed situations as well as looking at the overall ecology of such interactions in normal un-managed ecosystems.
There are 28 chapters, divided into 4 sections, on I. Impact of birds on fisheries, II. Bird, fish, habitat interactions, III. Mitigation measures, IV. Management.
This illustrated hardback book has 384 pages. You can order a copy at a special 20% discount price of £71.60 from Blackwell Publishing Direct Orders, c/o Marston Book Services on Tel: + 44 (0) 1235 465500, Fax: + 44 (0) 1235 465556, Email: direct.order@marston.co.uk and quote 'Cowx Trout News Special Offer'.

BTA NEWS

Jane Davis, Executive Officer, British Trout Assocaiation

Promotional activity

BTA promotional activity has changed significantly within the last nine months. The press office has been brought in-house, and as a result the operational costs have been significantly reduced. The main function of the press office continues to be the generic promotion of trout by way of identifying and creating editorial opportunities within the media. The core objectives remain unchanged: raise the profile of value added products, such as trout fillets and smoked trout; encourage purchases amongst new consumer groups; educate consumers on the health and nutritional benefits of eating trout and on the ease and convenience of cooking with trout.

The focus of the key messages emanating from the BTA office centre on the nutritional benefits of trout, particularly as a fish rich in omega-3 oils. Latest research news is converted into digestible chunks for regional and national newspapers and targeted consumer magazines, and together with commissioned recipes, circulated to media contacts. Personal touches and relationship building are a must and help secure good results.

BTA's commissioned recipes that are usually taken up by regional press and low volume consumer magazines, help reinforce a contemporary image of trout as a light, healthful and convenient meal choice. The target audience for our key messages include: families, particularly children's meals and quick suppers (fillets);

the health conscious and/or time constrained (fillets, whole fish); and for smoked trout those interested in the luxury health message.

EU Trout Market Studies

Two recently published EC studies '*An Analysis of the Farmed Trout & Seabream Supply Chains in the Main EU Markets*' and '*Consumer demand in France, Italy & the U.K. for farmed trout and sea bream and the impact on health and perceptions*' by GIRA Consommateur, have made some very stark statements about the state of the market for farmed rainbow trout across Europe.

The most succinct of these is that trout exhibits stagnant consumption and a very fragmented production base which has no resources for market development. On a positive note, the study reveals that in the UK, consumers consider trout farming to be beneficial. The consumer's rationale behind this statement is that the farming process allows for greater health controls and also that trout farming is a civilised undertaking. According to the report, the UK consumer would be happy to see farmed fish fed diets with a higher vegetable and lower fish content, regardless of the 'natural' diet of the fish. The UK consumer also believes that happy animals, including fish, taste better. The report suggests that the UK consumers' interest in farmed animal welfare stems from this belief and is what drives consumer concern of intensive fish farming.

63% of UK consumers (40% of French) believe that the trout they eat are farmed, while 80% (30% of French) show a degree of interest in what the fish are fed. Only 20% of UK consumers (56% of French) are prepared to believe that a 'mad fish' outbreak could happen.

Attendees of the 2003 Trout Farming Conference will have the opportunity to question the Consumer Demand report's consultant, Mr. Andrew Cookson, when he presents his report at Sparsholt this September. Copies of the full reports are available to download from the BTA members' website, or from the BTA office.

Socio Economic Study

The BTA has recently re-issued an annual costs and earnings questionnaire to its members to inform an update of the *Socio-Economic Study of the Trout Industry*, first conducted by Nautilus Consultants in 2001. Non-BTA member farms submitting completed questionnaires will be issued with a full copy of the updated study. Those interested in participating are requested to contact the BTA office.

AGM

The BTA's 2002/2003 Annual General Meeting will be held during the Trout Farming Conference at Sparsholt College, Hampshire on Thursday 4 September 2003. The Officers of the Association will deliver brief activity reports on the 2002/2003 year and attendees will have the opportunity to raise subjects of interest.

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

Cordinator 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

DEFRA/BTA FUNDED RESEARCH

UK R&D POST LINK PROGRESS

Mark James, Fisheries Resource Management Ltd, Coillie Bhrochain,
Bonskeid, Pitlochry Perthshire, PH16 5NP.

The LINK programme is now largely over. The only remaining trout related LINK project – TRT12 ‘Selective improvement in rainbow trout: mass selection and markers’, is progressing well and is due to end in June 2004.

A number of the co-ordination functions that the LINK programme provided are now being conducted through the Committee for Aquaculture Research and Development (CARD). This is a pan UK body which engages all the main industry trade associations together with the principal sponsors of R&D in this sector. CARD is a forum where the industry is encouraged to prioritise and justify the applied research that it believes is required in support of the industry. The sponsors who attend CARD are asked to consider industry’s requests for R&D and either sponsor projects directly or at least bear these priorities in mind when considering applications for funding.

Defra is allocating some £1 million over the next five years to support aquaculture R&D prioritised through CARD. Fisheries Resource Management Ltd (FRM) have been contracted to manage this budget and the projects supported by Defra. After the last CARD meeting in March, Defra considered the various requests for R&D from the trout sector and has decided, in principle, to sponsor work in the following areas:

Whitespot:
Defra is keen to support a project which will involve the field testing of potentially efficacious compounds against Whitespot, which were discovered during LINK project TRT06 – Assessment of chemical and potential immunological control methods for *Ichthyophthirius multifiliis.*

Selective Breeding – Rainbow Trout:
The trout selective breeding project - LINK project TRT12, is ongoing, but requires additional resources to undertake genotyping work.

Stocking Density and Fish Welfare – Rainbow Trout:
Defra is considering providing additional resources requested to extend on-farm work being conducted under an existing Animal Health and Welfare project (AW1203).

Malachite Residues:
Defra is currently considering a proposal to assess the persistence of malachite green/leucomalachite green in the aquatic environment.

Dr Mark James of FRM will be liaising with the various sponsors and project partners over the coming months to take these proposals forward.

As Defra has responsibilities for England and Wales with respect to much of the R&D commissioned, it is clear that the trout industry is well placed to benefit. Vital to developing a robust and defendable research and development portfolio which will underpin the future of the trout sector are the dedicated individuals who represent the industry at fora such as CARD. For many years, Professor Niall Bromage of the Institute of Aquaculture fulfilled this role admirably – his untimely death has robbed the industry of an astute and passionate advocate.

In Scotland, the long awaited strategic framework for aquaculture was launched on 24 March 2003. With respect to R&D the framework supports the setting up of the Scottish Aquaculture Research Forum (SARF). The format and structure of this Forum has yet to be agreed, together with any funds to support R&D. Whilst the concept of SARF has been broadly welcomed, it is important that this forum together with other similar groupings, complement each others activities, rather than duplicating effort and diminishing the impact of ever more scarce resources.

Through CARD, Defra is also supporting the development of an aquaculture R&D database. All the principal sponsors of R&D have agreed to provide information on the research they are funding for a period of up to two years in the first instance. The data will be published on the Defra website, and will be updated every six months. The database will be live by the end of June and will serve as an important resource, to all those with an interest in aquaculture research in the UK.

RESEARCH NEWS

1. Fish welfare briefing paper published by Fisheries Society of the British Isles

This briefing paper considers how welfare is defined and measured, and examines how various human activities affect fish welfare. ‘Animal welfare’ is a difficult term to define precisely. Different definitions focus on an animal’s condition, on its subjective experience of that condition and/or whether it can lead a natural life. These various definitions are not right or wrong, but simply highlight different aspects of welfare. A big unresolved and controversial issue in welfare research is whether fish experience what humans would call suffering when they are exposed to adverse events such as physical injury or confinement. That part of the brain (the neocortex), which generates the subjective experience of suffering in humans, is lacking in fish. However, other parts of the fish brain are well developed and are used to produce complex behaviour, so lack of a neocortex does not mean fish cannot experience some kind of suffering. Recent studies suggest that fish have the capacity to perceive painful stimuli and that these are strongly aversive. Consequently, injury or experience of other harmful conditions is a cause for concern in terms of welfare of individual fish. An overview of the available information tells us that various human activities - anthropogenic changes to the environment, commercial fisheries, recreational angling, aquaculture, keeping ornamental fish and scientific research - can harm fish welfare. It can be misleading to extrapolate general criteria for welfare of mammals and birds to fish. Fish do not need to fuel a high body temperature, so effects of food deprivation on welfare are not so marked. For species that live naturally in large shoals, low rather than high densities may be harmful. On the other hand, fish are in intimate contact with their environment through the huge surface area of their gills, so they are particularly vulnerable to poor water quality and pollution. Effects depend upon the species concerned (e.g. farmed Arctic charr do better at high densities but farmed trout do worse) and that they are context dependant (e.g. negative effects of stocking density may disappear if water quality is good.). If an activity does cause harm to fish welfare, this does not necessarily mean that it should be stopped; the harm represents a cost that should be minimised and weighed against the benefits of the activity concerned.

Reference

FISHERIES SOCIETY OF THE BRITISH ISLES (Granta Information Systems, 82A High Street, Sawston, Cambridge CB2 4H, UK; www.le.ac.uk/biology/fsbi/welfare) (2002). FSBI Fish Welfare. Briefing Paper 2.

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2. Evidence that rainbow trout have a sensory system for detecting noxious stimuli

Nociception is the detection of a noxious tissue-damaging stimulus and is sometimes accompanied by a reflex response such as withdrawal. Pain perception, as distinct from nociception, involves physiological and behavioural changes, and has been demonstrated in birds and mammals but has not previously been studied systematically in lower vertebrates. This study assessed whether rainbow trout possess nociceptors capable of detecting noxious stimuli and whether physiology and behaviour were affected by the administration of a noxious stimulus. Electrophysiological recordings from nerves identified nociceptors on the head of trout with physiological properties similar to those described in higher vertebrates. These receptors responded to mechanical pressure, temperatures in the noxious range (more than 40°C) and 1% acetic acid, a noxious substance. In higher vertebrates nociceptive nerves are either A-delta or C-fibres with C-fibres being the predominating fibre type. However in the rainbow trout A-delta fibres were most common. Administration of noxious substances to the lips of the trout affected both the physiology and the behaviour of the animal, resulting in a significant increase in opercular beat rate and the time taken to resume feeding, as well as anomalous behaviours. This study provides significant evidence of nociception in teleost fishes and furthermore demonstrates that behaviour and physiology are affected over a prolonged period, suggesting discomfort.

Reference

SNEDDON, L.U. (Roslin Institute, Welfare Biology. Roslin, Midlothian, EH215 9RS, UK. Email: lsneddon@liverpool.ac .uk), BRAITHWAITE, V.A. & GENTLE, M.J. (2003). Do fishes have nociceptors? Evidence for the evolution of a vertebrate sensory system. *Proceedings of the Royal Society of London B* 270, 1115-1121.

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3. Stocking density may affect trout growth via food intake

This study examined the effects of stocking density and food accessibility on growth, feed intake and feed utilization of rainbow trout. Densities ranged from 25 to 100 kg/m^3, and fish were fed either to excess via belt-feeder or by self-feeders with the reward level either fixed or proportional to fish density. Increasing fish density reduced food intake and growth, but not nutrient retention or body composition. From the combinations of feeding technique and density, the authors concluded that the reduction in growth with increasing density was entirely due to a reduction in feed intake per individual fish. They also suggested that rainbow trout adapt to crowding by reducing appetite and, as energy expenditure did not increase with increasing density, crowding *per se* was not stressful to the fish.

Reference

BOUJARD, T. (Equipe Nutrition Aquaculture Environnement, Unité mixte INRA – Ifremer de Nutrition des Poissons, BP 3, 64310 Saint Pée sur Nivelle, France. Email: boujard@paris.inra.fr), LABBÉ, L. & AUPÉRIN, B. (2002). Feeding behaviour, energy expenditure and growth of rainbow trout in relation to stocking density and food accessibility. *Aquaculture Research* 33, 1233-1242.

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4. Density and number of infectious fish affect survival during IPN outbreak

Two laboratory studies compared the effect of fish density and number of infectious fish (i.e. pathogen concentration) on survival of rainbow trout fry during controlled epidemics of infectious pancreatic necrosis (IPN). When the number of infectious fish was low and fish density increased, the peak death rate increased, time of the peak death rate decreased and the probability of survival to the end of the experiment decreased. When number of infectious fish was high, the effect of density diminished. Further analysis of survival data revealed that fish density, number of infectious fish and interaction between these two variables significantly affected time to death from IPN.

Reference

BEBAK-WILLIAMS, J. (Freshwater Institute, Shepherdstown, West Virginia, USA. Email: j.bebak@freshwaterinstitute.org), MCALLISTER, P.E., SMITH, G., BOSTON,. R. (2002). Effect of fish density and number of infectious fish on the survival of rainbow trout fry, *Oncorhynchus mykiss* (Walbaum), during epidemics of infectious pancreatic necrosis. *Journal of Fish Diseases* 25, 715 –726.

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5. Artificial photoperiod can influence the immune system and cause a stress response

Artificial photoperiod is used to enhance or delay natural spawning periods and smolting, to feed at night and to reduce precocious maturation. Nevertheless, the effects of photoperiod manipulation on other aspects of the physiology have not been fully evaluated. This study investigated the influence of artificial photoperiod regimes on the immune system of juvenile rainbow trout. Experimental fish were exposed to different photoperiod regimes for 140 days: 14 acclimatizing days at LD 10:14, 60 days at LD 24:0, 30 days at LD 10:14 and 30 days at LD 12:12. Control fish were kept at a 'natural' photoperiod of 14 acclimatizing days at LD 10:14, 92 days at LD 10:14 and 30 days at LD 12:12. Immunosuppression occurred in the experimental fish as measured by a decrease of mitogen-induced polyclonal expansion of T lymphocytes. This suppression was evident during the second month of the artificial photoperiod regime (LD 24:0 for 60 days, starting during late autumn) and rapidly normalized after finishing this protocol. Furthermore, a significant enhancement of this type of response could be observed in B lymphocyte populations of experimental fish when the natural photoperiod regime was resumed. Significantly elevated plasma cortisol levels corroborate that stress was present in the experimental fish. This indicates that a prolonged change in the natural photoperiod adversely affected the rainbow trout immune system, and that in spite of this, fish are rapidly capable of resuming normal function. On the other hand, hematological observations show that only thrombocyte numbers are significantly lowered by artificial photoperiod regimes, whereas the numbers of lymphocytes and erythrocytes did not show significant changes.

Reference

LEONARDI, M.O. (Department of Zoology, University of Concepción, POB 160-C, Concepción, Chile. Email: mleonard@udec.cl) & KLEMPAU, A.E. (2003). Artificial photoperiod influence on the immune system of juvenile rainbow trout (*Oncorhynchus mykiss*) in the Southern Hemisphere. *Aquaculture* 221, 581-591.

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6. Use of ozone to reduce saprolegniasis in trout hatcheries

There is increasing regulation limiting the use of products that have an impact on the environment. Malachite green, in particular, a specific treatment for the control of saprolegniasis, has been banned in Italy since 1994 and at present, the prophylactic measures in trout hatchery are based on the use of formaldehyde. There is therefore a need for new methods to control fungi pathologies in freshwater hatcheries. The purpose of this work was to study the effectiveness of ozone as a fungicide to control the incidence of saprolegniasis during trout egg incubation. The first experiment lasted 46 days with five different treatments applied on every second day - ozone (O_3) in concentrations of 0.01, 0.03 and 0.2 ppm (10 min); a reference treatment with formaldehyde (1–2 ml/l, 15 min); a control without any disinfectants. The second experiment lasted 60 days and consisted of six treatments - 0.01 ppm O_3 (10 min) applied on every second day; 0.01, 0.1 and 0.3 ppm O_3 (10 min) applied daily; a formaldehyde treatment (1–2 ml/l, 15 min) applied every second day. The use of ozone at 0.01 to 0.2 ppm proved effective, with hatching success ranging from 43% to 49%. The dose of 0.3 ppm applied every second day seemed to be over the toxicity threshold.

Reference

FORNERIS, G. (Dipartimento di Produzioni Animali, Epidemiologia ed Ecologia, Università di Torino, Via Leonardo da Vinci 44, 10095, Grugliasco, Torino, Italy. Email:forneris@veter.unito.it), BELLARDI, S., PALMEGIANO, G.B., SAROGLIA, M., SICURO, B., GASCO, L. & ZOCCARATO, I. (2003). The use of ozone in trout hatchery to reduce saprolegniasis incidence. *Aquaculture* 221, 157-166.

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7. Persistence of infectivity of *Tetracapsula bryosalmonae* spores

Proliferative kidney disease (PKD) is caused by the infection of susceptible salmonid fish with spores of the myxozoan *Tetracapsula bryosalmonae*, a parasite harboured and released by several species of bryozoans. Under natural conditions, PKD is a water-borne infection of fish, whose outcome and spatio-temporal dissemination depend on the viability of spores present in the water. In order to evaluate the duration of parasite infectivity, juvenile rainbow trout were exposed for 20 h to *T. bryosalmonae*-infected water at various times post-water collection or after different filtration procedures. When infected water was held in a temperature range of 14.5-17°C for up to 14 days, PKD was transmitted to the fish only between 0 and 12 h post-water collection and its infectivity vanished between 12 and 24 h. Similarly, the infectivity of water passed through 25 µm but not through 1 µm mesh filters, and was lost in the material eluted from the 1 µm filtration membrane although the parasite's DNA was amplified from this material. The parasitic infectivity in water therefore appears to be fragile and this may offer opportunities to decrease the impact of PKD in trout farms. This may be carried out by the implementation of management procedures aimed at reducing the number of bryozoan-holding surfaces such as submerged vegetation, large woody debris and various bryozoan-colonized substrates for some hundreds of metres in channels located immediately upstream of a given farm.

Reference

KINKELIN, P. DE (Institut National de la Recherche Agronomique (INRA), Unité de Virologie et d'Immunologie Moléculaires, Pathologie Infectieuse et Immunitré de Poissons, Jouy-en-Josas, France. Email: kinkelin@jouy.inra.fr), GAY, M. AND FORMAN, S. (2002). The persistence of infectivity of *Tetracapsula bryosalmonae*-infected water for rainbow trout, *Oncorhynchus mykiss* (Walbaum). *Journal of Fish Diseases* 25, 477-482.

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8. Record of an unusual bacterial trout disease in Scotland

During July and August 2002, approximately 30% of rainbow trout (weight = 15-20 g) from a fish farm in Scotland displayed tail and fin rot, and ulceration on the flank. The single circular ulcers, which were 10-15 mm in diameter, often extended completely through the abdominal muscle, exposing the underlying organs. In addition, most affected fish displayed pale gills. There was an absence of internal disease signs and the fish fed normally, although most of the ulcerated fish eventually died. Gram-negative highly motile rods were identified from cultures, and pathogenicity was confirmed by intramuscular injection. However an acceptable identification was not achieved through bacteriological and genetic testing, with the possibility that this organism represents a novel pathogen of which diagnosticians should be aware.

Reference

AUSTIN, D.A., JORDAN, E.M. & AUSTIN, B. (School of Life Sciences, John Muir Building, Heriot-Watt University, Riccarton, Edinburgh. EH14 4AS, UK. Email: b.austin@hw.ac.uk) (2003). Recovery of an unusual Gram-negative bacterium from ulcerated rainbow trout, *Oncorhynchus mykiss* (Walbaum), in Scotland. *Journal of Fish Diseases* 26, 247-249.

9. Probiotics improve survival against furunculosis

There has been increasing interest in the possible use of probiotics in aquaculture, in which micro-organisms are generally administrated as live supplements in feed. In this study, aerobic heterotrophic bacteria were isolated from the intestinal contents of Atlantic salmon and rainbow trout. Of the 177 isolates, 11 (6% of the total) inhibited the growth of cultures of *Aeromonas salmonicida*, the cause of furunculosis. Four of these isolates, which were identified tentatively as *A. hydrophila, Vibrio fluvialis, Carnobacterium sp.* and an unidentified Gram-positive coccus, where shown to be harmless to trout and stimulated feeding. Feed supplemented with the putative probiotics indicated survival of the organisms in the gastrointestinal tract for 7 days. Feeding with the probiotics for 7 and 14 days increased survival following challenge with *A. salmonicida*. There was no indication of serum or mucus antibodies to *A. salmonicida*, but there was an increased number of erythrocytes, macrophages, lymphocytes and leucocytes, and enhanced lysozyme activity in the fish.

Reference

IRIANTO A. & AUSTIN, B. (Department of Biological Sciences, Heriot-Watt University, Riccarton, Edinburgh, EH14 4AS, UK. Email: b.austin@hw.ac.uk) (2003). Use of probiotics to control furunculosis in rainbow trout, *Oncorhynchus mykiss* (Walbaum). *Journal of Fish Diseases* 25, 333 – 342.

10. Trial of oral delivery of antibodies to rainbow trout

The possibility of passively immunizing fish by injecting specific antibodies to various bacterial diseases has previously been investigated. However, such a strategy is labour intensive, and oral administration of antibodies would represent an easy and low stress alternative method of immunization. This study evaluated a new product called oralized fish serum concentrate (OFSC) – produced from the blood serum of immune trout - for a possible effect against bacterial pathogens in rainbow trout. The antibodies detected in the serum concentrate were specific to *Vibrio anguillarum* and *Aeromonas salmonicida*, with which the source fish had been vaccinated prior to serum collection. Storage of OFSC for 6 weeks at -20ºC, 5ºC or 20ºC did not reduce the functionaility of the specific antibodies. The OFSC was mixed with commercial trout feed and fed to rainbow trout fry for 1 month. Functional antibodies were identified in samples of gut content and gut tissue. However, no functional antibodies were identified from gutted fish suggesting that the antibodies in OFSC are unable to be transferred across the gut wall in a functional state. The authors suggest that serum enriched feed could have a prophylactic effect against pathogens which infect through the gut, although oral administration of OFSC did not increase survival of rainbow trout from *Vibrio anguillarum* in an immersion challenge.

Reference

NIELSEN, M.E. (The Royal Veterinary and Agricultural University, Department of Veterinary Microbiology, Section of Fish Diseases, Stigbøjlen 4, DK-1870 Frederiksberg, Denmark) & BUCHMANN, K. (2003). Effects of oral administration of specific antibodies to rainbow trout *Oncorhynchus mykiss*. *Journal of the World Aquaculture Society* 34, 11-17.

11. Disease resistance and lysozyme activity

The significant genetic variation in disease resistance found in salmonid fish opens the possibility of increasing disease resistance by selective breeding. Direct selection to improve disease resistance based on challenge testing is costly and laborious however, and indirect selection based on more easily measured traits that are genetically correlated to disease resistance is therefore of great interest. Lysozyme is part of the non-specific immune system and its relative activity level, like that of cortisol, is affected by stress. As part of a project where rainbow trout were selected for consistently high or low levels of cortisol and lysozyme this study evaluated the possibility of using serum lysozyme activity as a selection criterion to improve disease resistance. Both the high and low selected lines were tested for disease resistance against *Aeromonas salmonicida* and *Vibrio anguillarum* (the causative organisms for furunculosis and vibriosis respectively) and for humoral immune responses to these pathogens after vaccination. Two challenge experiments were undertaken by intra-peritoneally injecting doses of each pathogen. Following injection with *A. salmonicida*, the mortality was significantly different between the two lines in both experiments, with higher mortality in the high-lysozyme line compared to the low-lysozyme line. The difference between lines was particularly pronounced during the first days after injection. Following injection with *V. anguillarum*, the mortality showed no significant difference between the lysozyme lines. After vaccination, the levels of antibodies against both *A. salmonicida* and *V. anguillarum* and total amount of IgM were significantly higher in the high-lysozyme line, whereas no difference between lines was seen before vaccination. Selection for lysozyme activity appears to affect both the immune system and the disease resistance of rainbow trout. The prospects of using lysozyme as a selection criterion to improve disease resistance is, however, complicated by the fact that the association between lysozyme activity and the disease traits seems to be highly influenced by the immune status of the fish at the actual moment of sampling blood for lysozyme assessments. Thus a more detailed knowledge of the pertinent immune status of the fish is required before the effect of selection can be unambiguously ascertained.

Reference

RØED, K.H. (The Norwegian School of Veterinary Science, P.O. Box 8146, Dep., N-0033 Oslo, Norway. Email: knut.roed@veths.no), FEVOLDEN, S.E. AND FJALESTAD, K.T. (2002). Disease resistance and immune characteristics in rainbow trout (*Oncorhynchus mykiss*) selected for lysozyme activity. *Aquaculture* 209, 91-101.

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12. Selective breeding for stress response

An enhanced tolerance of stressful procedures may have the potential to improve various performance characteristics of cultured fish, although as yet there is no conclusive evidence to suggest that this really is the case. Elevated cortisol levels are known to be a direct causal factor in many adverse effects of stress, and the concentration of lysozyme, a non-specific immune trait with bacteriolytic effects, has also been shown to alter in fish following a stressful stimuli. The aims of the present breeding project have been (i) to compare the feasibility of selecting for post-stress cortisol and lysozyme responsiveness, (ii) to evaluate the inter-correlation between the two traits, and (iii) to compare the performance of fish selected for either of the two traits. Progeny groups of rainbow trout selected for high or low post-stress levels of plasma cortisol, or similarly for high or low post-stress lysozyme activity, were tested for their response to the selection. In all four of the stress exposures, individuals from the line selected for high cortisol responsiveness displayed significantly higher levels of post-stress cortisol than individuals of the low responding line. Only in two of the four stress experiments did the high lysozyme selected line exhibit significantly higher lysozyme activity than the low lysozyme line. There is qualified support for better growth performance in the low cortisol responding line as compared to the high responding line. The data are not conclusive as to establishing whether selection for altered post-stress lysozyme activity affects growth. In conclusion, the present data confirm that the progeny inherit stress-related traits identified in the parents; the response to selection for both cortisol and lysozyme is encouraging. The practical implications or gain of selecting for either trait under aquacultural conditions is still being resolved.

Reference

FEVOLDEN, S.V. (Norwegian College of Fishery Science, University of Tromsø, N-9037 Tromsø, Norway. Email: sveinf@nfh.uit.no) , RØED, K.H. & FJALESTAD, K.T. (2002). Selection response of cortisol and lysozyme in rainbow trout and correlation to growth. *Aquaculture* 205, 61-75.

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13. Differences in performance characteristics between rainbow trout strains

The domestication of rainbow trout has led to the development of distinguishable isolated populations. In this study, five different strains of rainbow trout from the Northwest, USA were examined for variability in growth, immunological response, and genetic diversity. Growth rates for the different strains were monitored and compared for 28 weeks. Feed conversion ratios (FCR) and specific growth rates (SGR) were calculated for each of the strains. The different strains were also evaluated immunologically with infectious hematopoietic necrosis virus (IHNV), and their post-immunization antibody neutralization titres were monitored for 12 weeks. Using microsatellites, the genetic variability between the strains was examined from a representational sample of the population of each strain. Fastest growing strains grew to a set weight of 350 g more rapidly regardless of whether they were fed at a fixed rate or to apparent satiation. These faster growing strains also exhibited a lower FCR and higher SGR value, and higher percentage protein retention. The IHNV neutralization titres for the strains varied considerably. Genetically, the strains exhibited a pattern of wide divergence, with only 9 common alleles out of a total of 89 different alleles between the five strains. As expected, commercial aquaculture strains reared locally were genetically more similar, and strains that have undergone intense selection tended to have a strong correlation between reduced genetic variability, FCR, and SGR as compared to non-commercial strains.

Reference
Overturf, K. (USDA/ARS, Hagerman Fish Culture Experiment Station, 3059-F National Fish Hatchery Road, Hagerman, ID 83332, USA. Email: kennetho@uidaho.edu), Casten, M.T., LaPatra, S.L., Rexroad, C. III & Hardy, R.W. (2003). Comparison of growth performance, immunological response and genetic diversity of five strains of rainbow trout (*Oncorhynchus mykiss*). *Aquaculture* 217, 93-106.

14. Review of rainbow trout genomics

The rainbow trout is one of the most widely studied of model fish species. Extensive basic biological information has been collected for this species, which because of their large size relative to other model fish species are particularly suitable for studies requiring ample quantities of specific cells and tissue types. Rainbow trout have been widely utilized for research in carcinogenesis, toxicology, comparative immunology, disease ecology, physiology and nutrition. They are distinctive in having evolved from a relatively recent tetraploid event, resulting in a high incidence of duplicated genes. Natural populations are available and have been well characterized for chromosomal, protein, molecular and quantitative genetic variation. Their ease of culture, and experimental and aquacultural significance has led to the development of clonal lines and the widespread application of transgenic technology to this species. Numerous microsatellites have been isolated and two relatively detailed genetic maps have been developed. The development and analysis of additional genomic sequence data will provide distinctive opportunities to address problems in areas such as evolution of the immune system and duplicate genes.

Reference
Thorgaard, G.H. (School of Biological Sciences and Centre for Reproductive Biology, Washington State University, Pullman, WA 99164-4236, USA Email:thorglab@wsu.edu), Bailey, G.S., Williams, D., Buhler, D.R., Kaattari, S.L., Ristow, S.R., Hansen, J.D., Winton, J.R., Bartholomew, J.L., Nagler, J.J., Walsh, P.J., Vijayan, Devlin, R.H., Hardy, R.W., Overturf, K.E., Young, W.P., Robison, B.D., Rexroad, C. III & Palti, Y. (2002). Status and opportunities for genomics research with rainbow trout. *Comparative Biochemistry and Physiology B* 133, 609-646.

15. Linking growth rate to hormone levels (and genetic strain)

Various environmental, nutritional, genetic, and endogenous factors are known to affect fish growth. It is important to establish whether growth rate is related to endogenous levels of growth-promoter hormones, as they are likely to be under genetic control, and hence could be selected for in-breeding programs. Two strains of rainbow trout displaying large differences in growth rate were chosen to explore mechanisms that might affect growth capacity. These differences could proceed through differences in hormonal status and especially in anabolic hormones such as growth hormone (GH) or thyroid hormones (T_4 and T_3). There is evidence that growth hormone and thyroid hormones enhance fish growth by stimulating greater voluntary food intake (appetite), by improving food conversion and by stimulating protein synthesis. The objective of this work was to examine the hormone profiles of fast- and slow-growing strains of rainbow trout under different feeding regimes. Some fish were fed to satiation to establish routine feeding behaviour, whereas others were submitted to a restricted ration level to nullify the effect of feed intake, thereby allowing a comparison of the general metabolism of the fish. Finally, fish were submitted to a starvation period, which functioned as a test to amplify the capacity of the animals to maintain high levels of circulating hormones. Differences in growth rate between the two rainbow trout strains, when fed to satiation, could not be associated with differences in hormone levels. Nonetheless, fish of the fast-growing strain exhibited significantly higher circulating GH values than slow-growing fish, after the fasting period. Additional studies on the thyroid and GH systems, and the cellular response to these hormones are warranted to further characterize this aspect of the endocrine regulation of body growth in the two rainbow trout strains.

Reference
Valente, L.M.P. (DEBA, UTAD, Vila Real 5001, Portugal. Email: lvalente@utad.pt), Le Bail, P.-Y., Gomes, E.F.S. & Fauconneau, B. (2003). Hormone profile in fast- and slow-growing strains of rainbow trout (*Oncorhynchus mykiss*) in response to nutritional state. *Aquaculture* 219, 829-839.

16. Replacement of fish meal with poultry by-product meals

Fishmeal has long been used as the main protein source in salmon and trout feeds. However there are increasing global concerns about the long-term sustainability of using fishmeal in fish feeds. Fishmeal is becoming more expensive and in short supply worldwide, so it is important to identify less expensive and more sustainable ingredients. Feed manufacturers are therefore seeking alternative protein sources , including poultry by-product meal (PBM). Most PBM has a lower ash content than fishmeal, which is desirable in fish feeds because ash contributes to phosphorous levels in effluents. This study compared the apparent digestibility coefficients (ADCs) for rainbow trout of three types of PBM (feed grade, prime and refined) to two fishmeal (herring and menhaden) diets. The results showed that refined PBM had similar ADC values to herring meal, thus it has a similar nutritional value and can replace portions of herring meal in rainbow trout feeds. Furthermore, differences in ADC values between grades of PBM should dictate appropriate use levels in rainbow trout feeds.

Reference

CHENG, Z.J (Hagerman Fish Culture Experiment Station, University of Idaho, Hagerman, Idaho 83332 USA) & HARDY, R.W. (2002). Apparent digestibility coefficients of nutrients and nutritional value of poultry by-product meals for rainbow trout *Oncorhynchus mykiss* measured *in vivo* using settlement. *Journal of the World Aquaculture Society* 33, 458-465.

17. Effects of anaesthetics on feed intake of steelhead with an assessment of clove oil

Even though a body of literature exists about the effects of different anaesthetics on fish, no comparative information seemed to be available about their effects on feed intake after anaesthesia, which would be important to know especially in aquaculture. The authors compared the effects of three anaesthetics- clove oil, MS-222, and CO_2 - on feed intake and the stress hormone (cortisol) response in steelhead trout. They anaesthetised juvenile steelhead trout with the three anaesthetics, and then sampled them 4, 24 and 48 h later. Fish in all groups ate relatively well 4 h after anaesthesia. However, feed intake in fish treated with clove oil or MS-222 was lower than in the un-anaesthetised controls. Blood cortisol concentrations were elevated 48 h after anaesthetisation, but there was no difference between the three anaesthetic treatments throughout the experiment. The authors conclude that their results support previous findings that clove oil is a reasonable alternative to MS-222.

Reference

PIRHONEN, J. (Oregon Cooperative Fish & Wildlife Research Unit, Oregon State University, 104 Nash Hall, Corvallis, OR 97331, USA. Email: jpirhon@dodomail.jyu.fi) & SCHRECK, C.B. (2003). Effects of anaesthesia with MS-222, clove oil and CO_2 on feed intake and plasma cortisol in steelhead trout (*Oncorhynchus mykiss*). *Aquaculture* 220, 507-514.

18. Comparison of effectiveness of a variety of anaesthetics for salmon smolts

In this study, Atlantic salmon smolts (45 g) in freshwater (5.4°C) were exposed to water containing different concentrations of metomidate from 0 to 10 mg l^{-1}, clove oil (eugenol), Aqui-S™ (iso-eugenol) and Benzoak® (benzocaine) from 0 to 100 mg l^{-1}. All anaesthetic concentrations were mixed and expressed as mg l^{-1} in relation to the active substance of the various anaesthetics. Metomidate, clove oil, Aqui-S™ and Benzoak® were effective as anaesthetics for Atlantic salmon smolts at concentrations ≥ 2 mg l^{-1} (metomidate) and 30 mg l^{-1} (clove oil, Aqui-S®, Benzoak®). The fish entered behavioural stage 4 (failure to respond to external stimuli) within 6.2–2.2 min for metomidate concentrations from 2 to 10 mg l^{-1}, within 8.1–2.2 min (clove oil and Aqui-S™) and 17.4–3.0 min (Benzoak®) for concentrations from 30 to 100 mg l^{-1}. A concentration of 100 mg l^{-1} of Benzoak®, clove oil and Aqui-S™ caused the salmon smolts to enter stage 5 (arrested opercular activity) after 6.4 and 12 min of exposure, respectively. Metomidate solutions 2 mg l^{-1}, clove oil and Aqui-S™ solutions 20 mg l^{-1} prevented plasma cortisol elevation above resting level. Benzoak® (regardless of dosage) did not prevent plasma cortisol elevations above resting level. While the anaesthetics increased mean plasma lactate concentration significantly in nearly all experimental groups, no such changes in plasma glucose were evident in any of the experimental groups. The eugenol-based anaesthetics (clove oil and Aqui-S™) show promise to become effective anaesthetics, with good efficacy at low dosages and with stress-reducing capabilities. They are also inexpensive and easily obtained, and are organic substances safe for both environment and user.

Reference

IVERSEN, M. (Norwegian Institute for Nature Research, Tungasletta 2, N-7485, Trondheim, Norway. Email: martin.iversen@hibo.no), FINSTAD, B., MCKINLEY, R.S. & ELIASSEN, R.A. (2003). The efficacy of metomidate, clove oil, Aqui-S™ and Benzoak® as anaesthetics in Atlantic salmon (*Salmo salar* L.) smolts, and their potential stress-reducing capacity. *Aquaculture 221,* 549-566.

19. A review of effluent regulation and treatment in Europe

The production of salmonids in European land-based farms has increased significantly due to intensification attempts and better management. A survey of commercial trout farms using aeration/oxygenation and high-energy diets in southern Germany shows that improvements in fish farming have led to a significant decrease of waste production, especially in terms of amount of waste per ton of fish produced. Feed-derived wastes are solid wastes (uneaten and digested feed) and dissolved wastes as by-products of metabolism, which are mainly excreted by the gills and the kidneys (ammonia, urea, phosphate, etc.). At present, the specific amount of nitrogen and phosphorus released (kg t^{-1} produced) is only one-third compared with the load in the mid-eighties. As a consequence, the effluent load of the individual fish farm is declining despite the increased production. Typical conditions in intensive Norwegian and German flow through systems are flow rates of 100–300 l min^{-1} per ton of fish stock and effluent loads prior to treatment of 150–200 kg suspended solids (SS), 7 kg phosphorus and 40 kg nitrogen per ton of fish produced. An increasing number of land-based farms are installing effluent treatment systems in order to meet discharge consent requirements. Effluent solids are commonly removed by screens, such as intermittently back-washed disc or drum filters. Biofiltration as an integrated end-of-pipe device has proven high removal efficiency in a SW Germany based farm. Post-mechanical treatment, nutrient uptake by hydrophytes is sometimes applied in trout farms before discharging the effluent into the recipient. The diversity of regulations and standards controlling fish farming in Europe reflects the differences in environmental conditions, fish farming technology, species farmed, and quantity and nature of wastes discharged. In land-based farms, regulations typically include limitations on the amount of water to be abstracted and on the effluent volume and concentrations of nutrients and organic matter to be discharged. Most of the environmental legislation controlling fish farming has remained unchanged over the last decade. The Water Framework Directive was adopted by the EU countries in 2000 and is intended to provide protection for groundwater, coastal, estuarine and surface waters. Fish farming is not specifically addressed in the Directive but it will undoubtedly affect regulation of the industry.

Reference

BERGHEIM, A. (RF-Rogaland Research, P.O. Box 8046, 4068, Stavanger, Norway. Email: asbjorn.bergheim@rf.no) & BRINKER, A. (2003). Effluent treatment for flow through systems and European environmental regulations. *Aquacultural Engineering* 27, 61-77.

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20. US prototype device for removing particulates in raceways

The most common type of rearing unit for rainbow trout produced in the US is the flow-through raceway. This paper describes the development and testing of the ASSIST - The Appurtenance for Settleable Solids In-raceway SeparaTion (ASSIST) - a solids concentration system designed to remove settleable solid waste material from high-intensity raceway rearing units. The water treatment structure, which can be readily retrofitted into existing raceways, was designed to create rotational currents to aid in the concentration and collection of particulate waste material in situ. The ASSIST incorporated a drain line, which diverts a small fraction of the raceway flow to continuously remove the uneaten feed and faecal material from the collection area located at the effluent end of the raceway. Continuous removal of the collected particulates minimizes the leaching of soluble material from the solids into the water column. Based on scale model tests using analogous waste material, the ASSIST is expected to remove 40–50% of the settleable solids generated in commercial rainbow trout aquaculture while diverting 5–10% of the raceway flow.

Reference

WONG, K.B. & PIEDRAHITA, R.H. (Biological and Agricultural Engineering Department, University of California, Davis, CA 95616, USA. Email: rhpiedrahita@ucdavis.edu) (2003). Prototype testing of the Appurtenance for Settleable Solids In-raceway SeparaTion (ASSIST). *Aquacultural Engineering* 27, 273-293.

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21. Challenges and solutions for American trout industry

The U.S. trout industry is a mature, stable industry. Production of market-size rainbow trout averaged 25,000 metric tons per year between 1988 and 1999, with a range from 23,600 to 27,300 metric tons per year. Trout growers reported total sales in 1999 of $76.9 million, compared with an average value of $71.7 million ex-farm between 1988 and 1999. Total sales include food fish, fish for stocking, fingerlings, and eggs. Market-size fish (>30 cm and 340 g) comprised 84% of total sales in 1999. The challenge for the trout industry is to at least maintain current production and possibly expand. Where can this growth come from? Additional growth can result from value-added products and increased productivity of existing operations. This paper discusses the challenges faced by the trout industry, specifically, the market-sized sector as it looks to expand, and suggest possible solutions that address these challenges. Freshwater availability and environmental constraints, including effluent limitations and public concerns about environmental impacts, are the primary obstacles toward industry expansion. Given water quality and quantity requirements for trout, development of new facilities, based on current production techniques, is limited. Therefore, additional production must come from existing operations through greater intensification and increased efficiency. Development of improved strains, high-performance feeds, vaccines for disease control, and new production technologies will provide the potential for increased production. Value-added products increase revenues without requiring increased production. Product development and marketing will be key to product diversification and sales. Consumers increasingly demand convenient products that are quickly and easily prepared. Marketing efforts will need to focus on perceived value, brand identification, promotion, and service.

Reference

FORNSHELL, G. (University of Idaho, Twin Falls, ID 83301, USA. Email: gafornsh@uidaho.edu). (2002). Rainbow trout – challenges and solutions. *Reviews in Fisheries Science* 10, 545-557.

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22. Hatchery rearing affects brain development of rainbow trout

In this study, the authors examined the hypothesis that captive rearing affects the brain development of rainbow trout. They compared hatchery-reared and wild trout by measuring eight regions of the brain. Using a variety of statistical methodologies the authors showed that the brains of hatchery reared fish were relatively smaller in several critical measures than their wild counterparts. It is suggested that this work could provide an explanation for the observed vulnerability of hatchery fish to predation and their general low survival upon release into the wild.

Reference

MARCHETTI, M. P. (Department of Biology, California State University Chico, Chico, CA 95929, U.S.A. Email: mmarchetti@csuchico.edu) & NEVITT, G.A. (2003). Effects of hatchery rearing on brain structures of rainbow trout, *Oncorhynchus mykiss*. *Environmental Biology of Fishes* 66, 9-14.

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23. Poor survival of hatchery-reared brown trout after release

Hatchery reared 0+ year brown trout were released into a sea trout stream in June 1991 to compare the survival of wild and introduced trout during the freshwater stage from age 0+ to 2+ years. The introduced brown trout and their offspring were distinguishable from the local sea trout as they were homozygous for a genetic marker. The mean size of 0+ and 1+ year introduced parr was larger than 0+ and 1+ year wild parr, while 2+ year parr of both groups were of the same size. Survival rates of both introduced and wild parr increased with size up to c. 80 mm (1+ years), but then decreased. The introduced parr, however, had a significantly lower survival rate than the wild parr. The number of the introduced cohort decreased from 2200 at release in 1991 to 20 in March 1994, i.e. 1% of the original number. High mortality at the parr stage and additional mortality until the spawning, give a low probability for a genetic impact on the local population as long as releases are restricted, both in time and number of fish.

Reference

BORGSTROM, R (Department of Biology and Nature Conservation, P.O. Box 5014, N-1432, Ås, Norway. Email: reidar.borgstrom@ibn.nlh.no); SKAALA, Ø; AASTVEIT, AH. (2002). High mortality in introduced brown trout depressed potential gene flow to a wild population. *Journal of Fish Biology* 61, 1085-1097.

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24. Salmonid restocking

Stocking can be a cost effective method of enhancing salmonid populations, in particular where the aim is to restore populations or mitigate against developments. There are risks associated with any intervention and it is suggested that all stockings undergo risk screening in order to identify the high-risk areas. The main concern regarding stocking relates to the impact on the genetic fitness of the wild population, and proposals to minimise the impact while still maintaining a fishery are made. To ensure that the greatest benefit from a stocking programme is realised, stocking rates should be optimal for the type of habitat being stocked. How this can be determined is presented together with guidelines for stocking different types of habitat. Benefit, in terms of cost of adult return or per adult fish caught, enables comparisons to be made with other management options. Information on survival rates of wild and hatchery-reared fish, unit cost of production and the economic value of fish and fishing is summarised enabling simple estimates of cost: benefit to be determined.

Reference

APRAHAMIAN, M.W. (Environment Agency North West Region, Richard Fairclough House, Knutsford Road, Warrington WA4 1HG, UK. Email: miran.aprahamina@environment-agency.gov.uk), MARTIN SMITH, K., MCGINNITY, P; MCKELVEY, S & TAYLOR, J. (2003). Restocking of salmonids - opportunities and limitations. *Fisheries Research* 62, 211-227.

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25. Habitat requirements of salmon and brown trout

The distributions and abundances of trout and salmon are strongly influenced by their habitat. The habitat includes both abiotic and biotic factors, which interact in complex webs. Habitat probably has strongest effects during population bottlenecks, when the standing stock approaches the carrying capacity of the environment. The importance of depth, current, substrate, cover, and to a lesser extent, temperature and oxygen availability to the various stages of the life cycles of salmon and trout are reviewed. There is abundant evidence that the habitat requirements of salmon and trout overlap so there is scope for interactions between them depending on the spatial arrangement of habitats and the occurrence of bottlenecks. Trout tend to out-compete salmon except often in areas of particularly fast flows and, perhaps, remote from the riverbank. It is particularly important to understand where the bottlenecks to production lie, otherwise, there is a risk of manipulating habitat that is already in excess, or increasing numbers of a population that will subsequently be constrained, e.g. by over-wintering habitat. For this reason, it is prudent to accept that although manipulations of habitat may appear to be beneficial when considered locally, they should be measured and assessed where possible in terms of the production of returning adults and/or high quality smolts. Because of the complexity of interactions between salmon, trout, and the animals that eat them, it is at present difficult, or impossible, to derive good predictive models of the effects of manipulating habitats under many circumstances.

Reference

ARMSTRONG, J.D. (Fisheries Research Services Freshwater Laboratory, Faskally, Pitlochry, Perthshire PH16 5LB, UK. Email: j.armstrong@marlab.ac.uk), KEMP, P.S., KENNEDY, G.J.A., LADLE, M. & MILNER, N.J. (2003). Habitat requirements of Atlantic salmon and brown trout in rivers and streams. *Fisheries Research* 62, 143-170.

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26. Salmonid habitat management

Most of the river systems in the British Isles have been subjected to anthropogenic influence to varying degrees over recent times, in many instances leading to deleterious impacts on salmonid habitat to the detriment of populations. This paper considers the range of management options that can be utilised to overcome habitat degradation. When examining salmonid habitat management three areas need to be taken into account: water quality, water quantity and the physical structure of the riverine environment. Although discussed separately, it should be remembered that these components of habitat are inter-related, and should be viewed as a continuum. Water quality problems include pollution from point and non-point source pollutants, although major improvements in the former have been achieved in recent years via the legislative framework and further benefits may be anticipated from the introduction of the Water Framework Directive. However, diffuse forms of pollutant, notably silt, still remain a significant threat to salmonid habitat and are yet to be tackled in any meaningful way. Changes to modern agricultural and land management practices are urgently required. Water quantity is impacted upon in a number of ways ranging from abstraction, which may reduce flows, through to land-use and flood defence that may alter the shape of the hydrograph changing velocities and influencing stream power. Society's conflicting demands are bound to increase these pressures, although imaginative and integrated planning of schemes can avoid many deleterious impacts and actually provide benefits to salmonid populations, provided the ecological requirements of the species are taken into account. Arguably a more flexible and targeted approach to river regulation and abstraction would be beneficial to salmonid populations. Degradation of physical stream habitat has been widespread caused primarily by insensitive land-use practices, agriculture and flood defence. A significant commitment to consider long-term investment of resources will be required to negate the widespread deterioration in habitat caused by such damaging management techniques. Although a wide range of physical habitat restoration techniques have been demonstrated both in-stream and within the riparian zone with significant success, it is suggested that some form of land-use regulation is required to prevent further damage. Treating the root cause of the problems of deterioration with respect to water quality, quantity and physical habitat, and not just the symptoms, should be a fundamental priority for salmonid management in the 21st century.

Reference

HENDRY, K. (APEM Ltd., Enterprise House, Manchester Science Park, Lloyd Street North, Manchester M15 6SE, UK. Email: keithh@apemltd.co.uk), CRAGG-HINE, D., O'GRADY, M., SAMBROOK, H. & STEPHEN, A. (2003). Management of habitat for rehabilitation and enhancement of salmonid stocks. *Fisheries Research* 62, 171-192.

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