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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

2001 SURVEY OF TROUT PRODUCTION IN ENGLAND AND WALES

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During the first half of 2002, the inspection and monitoring programme of salmonid farms, undertaken on behalf of DEFRA and the Agriculture Department of the National Assembly for Wales under the European Council Directive 91/67/EC, was carried out. A total of 271 registered salmonid farm sites were visited during 2002. Of this total there were 14 sites with no sales of fish during 2001 but which continued to hold stock and 5 sites that failed to provide data or whose ownership changed and therefore no accurate data was available. In addition during the period 12 new farms were registered and 23 sites ceased trading and were deregistered during the year, though some of the latter still reported some production. The data included in this report and provided by the site owners therefore represents the production from a final total of 255 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 2001

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 2001 was 6563 tonnes from 92 farm sites. This figure is significantly higher than that for 2000 (5757 tonnes). A total of 183 farms produced rainbow trout for restocking fisheries or ongrowing purposes, this was an decrease of 2 sites on the 2000 numbers. These sites together produced 3062 tonnes during 2001, of which 2463 tonnes were restocking trout and 599 tonnes were fingerlings or yearlings for ongrowing. This figure represents almost a 10% decrease on the total restocking and ongrowing production recorded for 2000 (3427 tonnes). These changes in the levels of production may well be a reflection of the restrictions on the movement of livestock imposed due to the Foot and Mouth Disease outbreak. The recorded production of Rainbow Trout for the table market has increased by 14% from the last year while restocking production has decreased by 10%.

The overall rainbow trout production (combining table and restocking/ongrowing figures) for England and Wales in 2001 was 9625 tonnes, an increase of 441 tonnes on 2000 production. This demonstrates almost a 5% growth in total production in the industry.

Table 1. 2001 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	1	1	8	3	13	20	189	1,340
North East	2	6	13	9	30	1,029	302	6,986
North West	2	3	7	8	20	127	125	240
Midlands	3	1	12	1	17	9	430	120
Southern	4	5	16	6	31	1,572	186	250
South West	5	13	38	17	73	2,857	1,313	11,765
Thames	1	2	8	8	19	601	224	246
Welsh	1	4	24	5	34	349	293	3,846
Totals	19	35	126	57	237	6,563	3,062	24,794

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	21 (9)	152 (5)	60 (1)	0 (0)	0 (0)
North East	57 (17)	262 (9)	276 (4)	458 (3)	400 (1)
North West	31 (13)	120 (5)	122 (2)	0 (0)	0 (0)
Midlands	46 (13)	96 (4)	61 (1)	301 (2)	0 (0)
Southern	52 (18)	172 (9)	51 (1)	0 (0)	1,553 (4)
South West	133 (42)	611 (22)	674 (10)	661 (5)	2,246 (4)
Thames	20 (12)	195 (7)	133 (2)	0 (0)	473 (2)
Welsh	66 (23)	272 (13)	222 (3)	150 (1)	0 (0)
Totals	426 (147)	1,880 (74)	1,599 (24)	1,570 (11)	4,672 (11)
% Total Production	4.2	18.5	15.7	15.6	46.0
% Farms involved	55.1	27.7	9.0	4.1	4.1

Table 2 provides a breakdown of the trout industry in which farms are classified according to their scale of production. Data are combined for both rainbow and brown trout as many farms produce both species. 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 55% of the trout farms in England and Wales are in the 0-10 tonnes category but their combined output only accounts for 4.3% of total production, this remains the same as last years levels. The numbers of registered small farms during 2001 has decreased by 2 from 2000, while the numbers of slightly larger (51-100 tonne) farms and the largest farms (>201 tonnes) has remained roughly the same. 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 represents an annual increase of 11 % in the proportion of total trout production coming from these large farms. The South West area contains the highest number of farms (83) and produces the most trout of any region (Just over 42% of trout production) in England and Wales.

Production of other farmed salmonids

The 2001 production information for brown trout and Atlantic salmon is summarised in Table 3. Of the 271 registered salmonid farms producing fish during 2001, 116 sites produced brown trout in addition to rainbow trout and 15 sites produced brown trout only (a total of 131 sites – a decrease of 4 sites from 2000). Nine farms produced both trout and atlantic salmon and 12 sites concentrated on producing salmon alone, 3 of these farms recorded negligible salmon production in this year. Total production of brown trout in England and Wales has remained stable at 516 tonnes an increase of only 3 tonnes on the 2000 production. Only 4 sites recorded brook trout (*Salvelinus fontalinus*) production in 2001 – 2.8 tonnes were produced for the restocking market, a significant increase from last year's level of 0.3 tonnes. Only 1 tonne of Brook Trout was recorded as being produced for the table market and none were recorded as being produced for ongrowing purposes. Three sites continue to trial the production of Arctic Char, however, the production of this species is still not significant (0.93 tonnes to the on-growing trade and 0.32 tonnes for the restocking market).

Table 3. 2001 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	5	5	41	0	2	1	500	375
North East	17	15	113	94	3	0	780	0
North West	9	3	22	1	5	0	1,400	4,060
Midlands	12	9	58	13	2	0	0	2
Southern	26	19	65	0	2	0	177	345
South West	35	18	144	142	0	0	0	0
Thames	12	8	13	0	1	0	32	0
Welsh	35	18	61	154	5	1	171	167
Totals	151	95	516	405	20	2	3,060	4,949

Commercial units that supply farms in Scotland produced the majority of salmon smolts. A total of 2.2 million smolts were produced from nine sites, an increase of 0.4 million from last year and two more sites have moved into this type of production during the period. Five commercial sites also produced almost 219 thousand salmon parr. In addition, five Environment Agency salmonid rearing sites operated during 2001 to produce fry and juvenile salmon for specific river stock enhancement programmes. These sites together produced 106 thousand salmon smolts, just under ½ million salmon parr, just over 200 thousand salmon fry and 77 thousand sea trout fry. The numbers of salmon smolts produced by the EA sites has increased while the numbers of fry produced has slightly decreased from last years total, the numbers of sea trout have decreased by just over 10% on last years production. The changes in production from these sites suggest that the emphasis of Environment Agency salmon stock management towards the use of younger fish coupled with emphasis on habitat improvement programmes may have slowed down.

Ova production

The recorded figures for salmonid ova produced over the period running from late 2001 through to early 2002 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 28.5 million eggs, of which almost 8 million were sold to other sites. These figures represent an increase of 36% from the 2000/2001 season (21 million eggs) this is the first increase in such production after three years of decline. Mixed-sex rainbow trout egg production has fallen slightly from last years levels to 2.1 million eggs (just over 2.4 million were produced in 2000/2001). The recorded production of rainbow trout triploid eggs was just over 9.8 million, which is a 27% increase from the 2000/2001 level of 7.3 million. It would appear that the production of triploid eggs is still on the increase while the production of mixed sex eggs is beginning to stabilise. The overall increase in egg production from last years levels may well reflect an increase in the level of broodstock held following restrictions on fish movements\sales during the Foot and Mouth Disease outbreak.

The majority of brown trout ova produced were mixed-sex and production totalled just over 2.7 million ova, a decrease on last year's figures. Of this total, just under 579,000 (21%) were sold to other sites. A total of 200,000 all-female brown trout ova were produced, which is just 27% of the 2000 levels. Triploid ova production was recorded as 260,000 – a decrease of just over 50% on the last year's figure. This represents a decrease of just over 33% in the overall production of brown trout eggs from last year's level. While the Environment Agency's policy on trout stocking may have contributed to some uncertainty regarding future production of brown trout for restocking, the fall in numbers of all female and triploid eggs is surprising given that the Agency contends that the use of triploid fish may be the way forward for trout stocking.

5.6 million Salmon eggs were produced by commercial salmon rearing sites, this is a significant increase from 2000 levels. A further 0.8 million eggs were produced for Environment Agency stock enhancement programmes, a decrease of around 46% from last years levels. In addition, approximately 65,000 eggs from salmon broodstock obtained from the River Lune 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 the same number as in 2000.

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

Table 4. 2001/2002 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)

Environment Agency Area	Rainbow trout			Brown trout			Salmon
	All Females (thousands)	Mixed Sex (thousands)	Triploid (thousands)	All Females (thousands)	Mixed Sex (thousands)	Triploid (thousands)	Mixed Sex (thousands)
Anglian	250	100	0	0	100	0	40
North East	13,509	1,042	4,064	75	1,224	50	600
North West	0	1	0	0	300	0	5,391
Midlands	175	130	75	0	111	0	42
Southern	165	4	515	15	105	15	120
South West	11,052	541	2,383	110	468	195	0
Thames	3,310	0	2,800	0	202	0	0
Welsh	100	287	0	0	223	0	264
Totals	28,561	2,105	9,837	200	2,733	260	6,457

RAINBOW TROUT EGG IMPORTS IN 2001

Rainbow Trout egg imports into England and Wales during 2001 totalled 45.1 million (Table 1). This represents a decrease on the number of eggs imported from the previous year (50.8 million).

Table 1. Summary of Rainbow Trout eggs imported into England and Wales by month in 2001

Month	Northern Ireland	Isle of Man	Denmark	South Africa	Total
January		755,000			755,000
February		1,885,000			1,885,000
March		1,415,000	2,125,000		3,540,000
April		2,290,000	850,000		3,140,000
May		250,000	900,000		1,150,000
June	7,000			6,615,000	6,622,000
July	422,000			12,727,136	13,149,136
August	429,000			5,195,000	5,624,000
September	15,000	15,000		3,000,000	3,030,000
October	300,000	1,079,000			1,379,000
November		2,770,000			2,770,000
December		1,700,000	325,000		2,025,000
Total	1,173,000	12,159,000	4,200,000	27,537,136	45,069,136
Total %	2.6	27.0	9.3	61.1	100

2000 SURVEY OF TROUT PRODUCTION IN NORTHERN IRELAND

DANI inspect all fish farms twice per year under Council Directive 91/67 and Fisheries Act (Northern Ireland) 1966 during which data is collected. This is summarised in Tables 1 and 2.

230 tonnes of Rainbow Trout and 200 tonnes of Brown trout are produced for restocking.

Ova and fry/fingerlings surplus to requirements are exported.

Table 1. Rainbow trout table production

Production	No. of sites	Total production (tonnes)	Number employed (including hatcheries)		Sites not producing
			full time	part time	
0-9 tonnes	6	55	6	3	1
10-24 tonnes	8	210	10	8	2
25-49 tonnes	4	220	6	4	1
50-59 tonnes	5	440	6	4	-
100-199 tonnes	3	200	5	3	-
200 tonnes +	-	-	-	-	-
Total	26	1,125	33	22	4

Table 2. Ova production

No. of Hatcheries	Rainbow trout	Brown trout	Migratory trout
7	14,000,000		
3		1,500,000	
7			250,000

ARTICLES

BRITISH TROUT FARMING CONFERENCE
SPARSHOLT, 6-7 SEPTEMBER, 2001

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

The use of immunostimulants in fish

The opening presentation of the final day of the conference was given by Professor Jan Raa, Director of Science at Biotec ASA in Norway. With a background in microbial diseases and defence mechanisms in plants his current research interests include the development of vaccines and immunostimulants and its application to human disease control. The immune system is an animals defence against the invasion of micro-organisms and is composed of two parts – innate or natural (non specific) immunity and adaptive (specific) immunity. Natural immunity is the more powerful of the two systems (and the most important in man) and represents the evolutionary foundation of immunity. It is present in all animal groups from insects to man and functions by detecting and eliminating micro-organisms at an early stage of infection either by production of anti-microbial substances in skin and mucous or ingestion (phagocytosis) by white blood cells (macrophages). Adaptive immunity, on the other hand is found only in the higher vertebrates from boney fishes to man, representing just 3% of all animal species. This system is effective against specific diseases acquired as a result of previous infections. Here immunity develops slowly, in response to infections (or vaccination) and is only mobilised if the disease organism overwhelms the innate system by penetrating and multiplying within the body fluids. As a result antibody production by white blood cells specifically target and inactivate the disease organism.

Immune stimulants, he continued, are biological chemical substances produced from bacterial cell walls, bacterial DNA, mycelial fungi and bakers yeast which interacts with white blood cells (macrophages, granulocytes and natural killer cells) to stimulate there biological activities. The overall effect may be positive or negative depending on the particular receptors (so-called toll receptors) involved. They may mobilise the immune system leading to enhanced disease resistance by increased antimicrobial activity and cellular defence or produce a septic shock resulting in fever, reduced appetite and inflammation. Nutrients are not in themselves immune stimulants but they may affect its functioning by enhancing the efficacy of the stimulant eg glutamine is important in fish where it acts as a gut nutrient. Stimulants are able to activate the innate immune system fast and help mobilise the slower adaptive immune system.

Of all the immune stimulants the most studied are the glucans, he said, which are found in mycellial fungi and bakers yeast. Their chemical structure is well defined in which glucose acts as the only building block linked to other chemicals such as starch, cellulose and laminarin. The different glucans have different enhancing effects and all have been tested on a variety of animals. They not only enhance disease resistance but, in addition, act as an anti-inflammatory, increase the potency of vaccines (adjuvant affect), stimulate wound healing, promote growth and reduce feed conversion efficiency.

Research on glucans in fish started 15 years ago against Hitra disease in Atlantic salmon in Norway and was found to be highly successful. Glucans (MacroGuard) are now added to the feed in pigs and calves as well as salmon and trout. The growth promoting effect in fish, he said, resulted from reduced microbial stress leading to heavier feeding. MacroGuard is also used as a prophylactic in reducing the risk of disease after fish handling, temperature changes and other stressful events. In trout the use of MacroGuard in the feed also enhances performance at all stages of the cycle particularly growth and feed conversion efficiency as well as the immune response to disease, for example against Yersinia ruckeri after injection of the appropriate antibody.

Professor Raa concluded his talk by saying that natural acquired immunity in man was breaking down because of the sterile condition of modern living, resulting in too little stimulation of the immune system by ingestion of dust and dirt. This he considered was the route coarse of the rise in asthma. Soil was often eaten by animals containing bacteria and fungi which naturally stimulated the immune system.

The modern coarse fishery

Simon Scott of the fisheries studies section at Sparsholt college followed with a lively delivery on the modern coarse fishery: monsta or Mecca. His introduction outlined coarse angling as it was 50 years ago. This, he said, was mainly river fishing where a wide diversity of species was available to the angler, including roach, rudd, perch, bream, barbel, chub, pike and tench and some carp. Few still water fisheries existed at this time. Three categories of anglers could be recognised; specialists targeting carp, pleasure and match anglers. The basic tackle used was a split cane rod and centre pin reel.

The revolution in coarse angling stemmed from stocking a small lake near Ross-on-Wye with 7 inch carp in 1934, initially to help control weed growth. Subsequently named Redmire pool anglers began fishing the lake in 1950 when the carp had grown and two years later a record 44 lb common carp was landed by Dick Walker. The fish was eventually donated to London Zoo to help popularise carp fishing. Over the next 40 – 50 years clubs began stocking their waters with carp which soon became the most sought after fish.

The reasons for this popularity, he said, were not hard to see. Carp clearly grew very large (the current record is 59 lbs 12 ozes), more so than any other species and anglers liked catching big fish. In addition they were widely available and many thousands of lakes in Britain are capable of holding 20 lb fish and around 50 lakes now hold 40 lb + fish. Another great asset is that they grow quickly reaching 20 lbs in 5 years and much faster than this in cultivation. From an angling point of view carp are easy to catch, they feed all year round and can be caught between June and February. They also have a long life span and can withstand poor water quality and rough handling making them ideal match fish. Consequently the past ten years has seen a rise in commercial fisheries with an emphasis on stocking large specimen fish to attract anglers and increase revenue. This together with other facilities such as car parking, club houses with shower and bar facilities had resulted in the decline of traditional angling clubs.

Stocking rates were then considered which varied enormously across the angling spectrum. Gravel pits stocked at between 50 – 100 kg/Ha produce large fish but are hard to catch because of the presence of large quantities of natural food. Traditional club waters that are unmanaged and stocked at 300 – 500 kg/Ha have become very quiet over the last 10 years in favour of the commercial fisheries. Average commercial fisheries are stocked at around 1200 kg/Ha while highly stocked match fisheries may reach 6,000 kg/Ha and the most heavily stocked to date at 14,000 kg/Ha.

In association with the rise in these fisheries has been the development of specialised tackle dealers offering a vast array of sophisticated equipment catering solely for the carp angler. Another area was the bait industry supplying a wide range of products. He estimated that 10,000 tonnes of bait was used in coarse fisheries over the last year alone.

Turning to the future, he said the rise in 'fast fishing' had generated substantial revenues for fishery owners who saw increasing stocking rates as the way forward. This had resulted in overstocking of many fisheries creating water quality problems, disease and fish kills. Also because fish come to rely on anglers bait as their sole source of food they are frequently caught, often 4 – 5 times per week, resulting in hooking injuries around the mouth. This disregard for fish welfare by some fishery owners has resulted in a deterioration in public perception of the sport and some pressure groups such as People for Ethical Treatment of Animals (PETA) were now actively campaigning against angling. There was, he said a requirement to educate people, particularly anglers, over fish welfare and the Institute of Fisheries Management are currently producing a code of practice to address this need.

Automated humane slaughter of trout

The LINK project on development of an automatic humane slaughter system for trout was successfully concluded last October with the production of a working prototype that meets all the requirements for both welfare and carcass quality. Jeff Lines from the Silsoe Research Institute, Bedford, the project leader, outlined the working principles and operation of the machine which is now ready for commercial manufacture. There were many ways of killing fish, he said, but batch electro-stunning was considered the best way forward, in spite of the known problems associated with carcass quality using this method because it was instantaneous. The three variables to electric stunning – voltage gradient or current, duration of current and wave form or frequency was looked at to meet welfare aspects, cost and operator safety. Experiments indicated that at 3 volts/cm for 5 seconds duration at 50 Hz , trout recovered after 40 – 80 seconds and at higher frequencies fish recovered faster. Haemorrhages resulted from the current but not to the duration of current and over the frequency range 50, 500, 1000 Hz (cycles per second) damage was reduced at the higher frequencies. Some banding of the carcass resulted but this was reduced 30 minutes after killing. Further refinements of the electrical parameters indicated an acceptable stun that resulted in no carcass damage or recovery of consciousness could be achieved at 2.5 volts /cm at a frequency of 1000 Hz alternating current for a duration of 60 seconds.

The next thing to consider, he said, was how to implement these findings into a workable machine. Batch stunning was attractive because it required no moving parts and had a low capital cost but this would necessitate small batches of fish unless a high voltage or current was used, making the killing process relatively slow and compromising welfare. On the other hand a continuous flow machine involved a low labour requirement, could deal with large numbers of fish and maintain a high speed of throughput with good welfare.

The approach taken involved the construction of a water tank1.3 metres long within which a drum or carousel, divided into a number of channels, was made to rotate horizontally at 1 revolution per minute. Each channel, whose walls contained the stunning apparatus, held the fish in the electrical field for the duration of rotation and then flushed out into a bin. The electrical supply uses a signal generator and commercially available loud speaker amplifier at 4000 watts creating 40 amps current at 1000 Hz in the killing chambers. The result is a relatively small machine, simple to use and not too expensive which meets all quality and humane welfare criteria.

Selective Breeding

Another LINK project on selection improvement of rainbow trout was then described by Brendan McAndrew, Professor of Aquaculture Genetics at the Institute of Aquaculture, Stirling University. He outlined the difficulties of genetic improvement in aquatic animals and explained how, with modern technology, it was now possible to design and implement selection programmes based on sound genetic principles.

Rapid progress, he said, had been made over the last 30 years in the successful improvement in performance of all farmed animals and plants, as the understanding of the underlying genetic principles became known. Selection improvements in aquatic organisms was still rare, however, mainly because aquaculture was a young industry with many other problems to solve. It was also seen as a long term, expensive and generally too complicated for small producers. Consequently less than 1% of farmed fish are currently under any genetic improvement. An exception was carp, which had undergone a lot of genetic improvement through crossing between inbred lines for hybrid vigour, but geneticists were now changing their approach and looking at increasing genetic variation, not reducing it. In salmon, for example, the Norwegian approach was for mass family selection for growth rate in which a 10% genetic gain per generation had been achieved.

Historically the genetic management of fish stocks had been haphazard and unscientific. This green fingered approach, based on mass selection can cause potentially serious problems for long term sustainability of fish stocks, he said, The lack of standardisation produced a large source of environmental variation in individual performance, for example in hatch date, egg size, stocking density and grading to overcome size variation. In addition most fish species have high fecundity and therefore large families and any selection based on fish size could result from a small number of families leading to inbreeding depression. Values for inbreeding depression (F values) in rainbow trout range from 12.5 – 59.4 in which F = 25 is equivalent to brother x sister mating (full sib mating) and F = 50 equivalent to selfing (eg gynogenesis).
The basic requirement, he said was to identify the pedegree of an individual, compare the performance of a large number of fish and to minimise major environmental factors. This involved tagging individual fish after birth but cannot be done without growing them on first. Passive Integrated Transponder (PIT) tags costing 2$ each and measuring 10mm long are used. These are glass encapsulated micro chips which sends a 10 digit code when read by a transducer. The tag is inserted internally, can be re-used and does not set up any adverse reactions in fish. They also facilitate data collection, for example, by assigning fish weight to a tag number. The Atlantic salmon smolt producer Landcatch has extensive facilities for its genetic selection programme comprising 208 tanks each holding 10,000 fry. PIT tags are inserted at a fish weight of 30 grams and 100 fish from each family are tagged and reared per tank. The tagged fish are eventually transferred to commercial facilities for assessment of growth performance.

In the last few years molecular markers have been used to identify individuals. All the genetic information from each parent is contained in thousands of microsatellite loci on the chromosomes and by using a small number of these each individual can be assigned to its parent. Once the parents have been analysed (‘finger printed’, using scales or a small piece of fin) the progeny from several crosses can be reared together in the knowledge that each can be subsequently finger printed and its family origin identified. Offspring are then raised until large enough to assess the quality/ quantity of the desired trait and then fingerprinted, the best being selected from each family as potential broodstock for the next generation. In this way crosses between related fish can be avoided.

The benefits of using this technique, he said, is that it is relatively easy to carry out without the use of extensive facilities, allows novel breeding programmes to be designed and complete traceability of stock is possible from production through to processing. The expected improvement in performance of the genetic resource, year on year, is estimated to be in excess of 10% per generation with a reduction in variability of fish at harvest also expected.

He concluded with the progress made to far on the LINK project which had begun in June, 2001. Microsatillite markers had been identified and a questionnaire sent out to industry to identify breeding goals. Trials to identify the genetic variation present in the traits that may contribute toward breeding goals will be carried out and discussions on the requirements of processors and ongrowers in the UK and Northern Ireland had begun.

Pyceze – the malachite replacement

The long awaited marketing authorisation for Pyceze was granted provisional authorisation on July 12 last year. John Marshall, the clinical trials manager for Norvartis Animal Vaccines Ltd spoke on the objectives of the project and described the characteristics, efficiency and recommendations for the use of Pyceze and its current regulatory position.

The objective, he said was to produce a product that prevented fungal infections, particularly Saprolelgnia in salmonid eggs and fish, safe to use with no side effects and with a short withdrawal period. The active ingredient, 50% bronopol, is a broad spectrum anti microbial that blocks the thiol enzymes in cell membranes. Pyceze is marketed in 1 L bottles and protective gloves and an eyeshield should be worn when dispensing the product. Recommended dosage rates were 1 ml Pyceze per 10L of water (50 mg bronopol/L) for eggs and 1 ml per 25L of water (20 mg bronopol/L) for fish. Treatment duration must be 30 minutes and on a daily basis for eggs and for 14 consecutive days for fish, the aim being to achieve a therapeutic dose for the duration of the treatment period. Another option was the continuous addition of Pyceze in re-circulating systems for egg incubation. The procedure involved measuring the volume of the incubator, re-circulating water and flow rate, calculating the administration time (that is, time taken for the water to re-circulate round the system) and prepare a stock solution.

The efficacy of treatments on eggs was determined from clinical field trials using 12 commercial salmon and trout farms and involving a total of 1,351,000 eggs. These indicated that in the absence of egg picking, 94% of eggs were protectd from fungal infection. In fish 13 farms involving a total of 64 tanks and 25,878 fish treated for 14 consecutive days, starting when fungus was already evident showed mortality rates were significantly reduced compared to controls.

Finishing with the regulatory situation, he said an application for a Provisional Marketing Authorisation had been granted in July, 2001. Concerning discharge consents the Scottish Environmental Protection Agency had issued guidance notes to regional inspectors proposing a PNEC (predicted no effect concentration) of 10 µg per L.

EU Review of fish health regulations

This was the first presentation of the afternoon session, given by Barry Hill of CEFAS, Weymouth. This paper has been reproduced in full later in this issue and will not be discussed further here.

Fish medication

Fish medication was the next subject discussed by Peter Scott, Managing Director of Zoo and Aquatic Veterinary Group based in Winchester. Under the title "Fish medication: red tape and consumer protection", he dealt with the thorny problem of public concerns over human health issues involving residues from the medication of food animals, particularly those relating to fish. In dealing with these concerns he examined the protection afforded by legislation covering medicine licensing and usage and the necessary record keeping required both by farmers and prescribing veterinarians.

He began by asking why treat fish diseases? To not treat, he said, would be unacceptable on welfare grounds and hence the problems of residues and human health arise. The history of antibiotic use stemmed from Fleming's discovery of penicillin in 1929 but not until 1940 was its potency demonstrated by Florey. The term antibiotic was first coined in 1942 with oxytetracycline appearing in 1950 and synthetic penicillins in the 1960s and 70s.

Consumer concerns, he said, were driven by supermarkets telling their customers what they needed – greener, safer, fresher, happier, welfare friendly and cheap foods. Concerns over the use of medicines had been championed by the Soil Association with the publication of 'The Use and Misuse of Antibiotics in UK Aquaculture'. This was particularly concerned with growth promoters in animals and listed several antibiotics used in fish for this purpose.
Consumer protection is particularly concerned with infectious drug resistance in which organisms exposed to antibiotics develop a resistance that may, in some cases, pass between bacteria. The use of therapeutants was another potential problem area for human health through direct toxicity (malachite green), allergic reactions (penicillins) or infectious drug resitance (quinilones and chloramphicol).

Controls on the use of medicines come under two main routes – by licensing and veterinary constraints. The rules are laid out under the Medicines Act of 1968 and EU harmonisation on the regulations governing drug approvals has been required since January 1998. The two basic requirements are a marketing authorisation which determined the efficacy, quality and safety of a medicine and a maximum residue level (MRL) which is the maximum concentration of residue from the use of a medicine legally permitted as acceptable in food.

Each drug is assigned a category: Annex 1 requiring a full MRL, Annex 2 no MRL required (eg Bronopol) and Annex 3 in which no safe MRL can be sit. Some extrapolation is allowed to embrace the wide range of cultured species, for example salmonids are regarded as a single species and other fin fish species have the same MRL as salmonids.

Detection levels for residues started out as parts per million (mg/Kg) but as techniques improved these have increased to parts per billion (µg/Kg) and parts per trillion (ng/Kg). These, he said, were necessary as some drugs may have cumulative effects. However, the view of the Veterinary Medicines Directorate (VMD) was that with the setting of MRLs and the low incidence of residues found, the risk to consumers in the long term was extremely small.

Farmers have a range of advisers on disease control available to them including their own vet or commercial laboratory, feed company advisers and CEFAS inspectors. He was critical of the latter however, because results of government testing was not routinely passed to the farm vet, even when this was known by the inspectors, resulting in wasteful repetition and slowed response times. This did not happen in the case of cattle, sheep and pigs.

Veterinary involvement and the regulations governing the prescribing of drugs was then discussed with respect to medicated feedstuffs and the use of alternative drugs under the 'cascade' system. He finished by saying that farmers must now have approval to carry out on-farm mixing of medicated feedstuffs but to date it was unclear how his would be applied.

European Food Safety Inspection Service

The final presentation of the conference was given by Daryl Hill who spoke on the European Food Safety Inspection Service (EFSIS). This had been formed as a limited company in 1989 in collaboration between the Meat and Livestock Commission and Campden and Chorley Wood Food Research Association. With offices in Milton Keynes (head office), Chipping Campden and Stourport and on the European continent it provides an independent inspection service to the food, drink and allied industries covering the complete food chain from producer to retailer. The services offered include practical training for the retail and catering sectors leading to recognised qualifications and a comprehensive market intelligence service with regular publications of reports and fax, telephone on-line information. Contract research is also undertaken together with advice on legislation and product analysis. A qualified certification committee which is totally impartial and independent has sole authority for certification of the many industry schemes now under EFSIS accreditation which includes Scottish Quality Trout.

THE IMPORTANCE OF OXYGEN

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This article has been reproduced from the Spring 2002 edition of Trouw Outlook, the magazine from Trouw Aquaculture

One of the most important functions of the water supply to a fish farm is to provide the fish with oxygen. In fish culture facilities, the balance between oxygen consumption and oxygen supply is critical and is one of the most important factor in achieving good performances. This article will examine some of the issues encountered in a typical trout farming situation.

Oxygen content in water can either be expressed as mg/l or as a % saturation rate. Temperature affects the dissolution of oxygen in water where an increase in temperature reduces the ability of water to carry oxygen. Mg/l gives the amount of oxygen present in a given volume of water whilst % saturation rate expresses how much oxygen is dissolved in relation to the amount that can be dissolved at a given temperature. The saturation % indicates how available oxygen is to the fish as it expresses the gas pressure which determines the transfer of oxygen over the gill membranes.

Fish Size

The amount of oxygen consumed by fish is a function of its size, feeding rate, activity and temperature. Having a higher metabolic rate, small fish consume more oxygen per given bodyweight than larger fish and small fish are able to eat more per given body weight. However, contrary to popular belief, smaller fish need lower oxygen saturation rates than bigger fish. Even though they eat more and have a higher consumption per given body weight, they are able to transfer oxygen

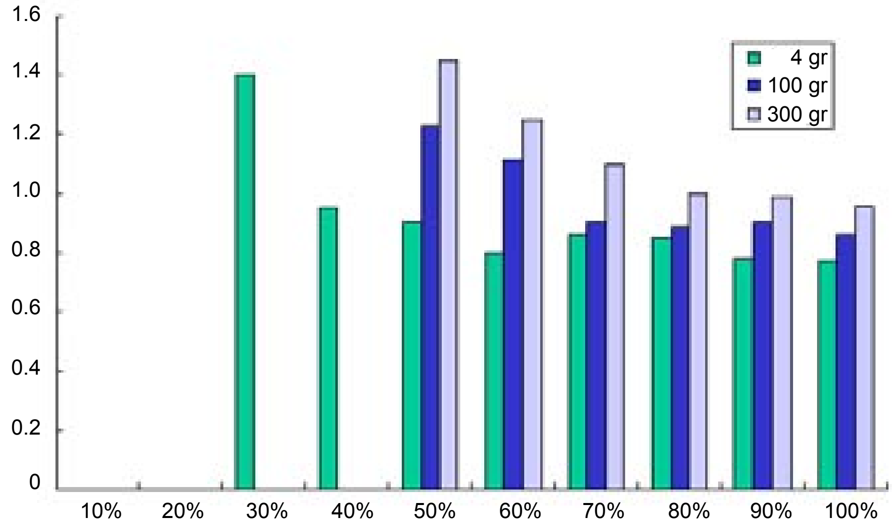

Figure 1. Oxygen's influence on FCR

more efficiently over their gill membranes at a lower gas pressure than larger fish. This is because their gill surface area versus body weight is higher and their gill epithelium is thinner and more permeable for oxygen. This means that there will be different minimum oxygen thresholds for different sizes of fish; the smaller the size of fish, the lower the oxygen threshold.

For example, there is little difference in growth rate and FCR at oxygen saturation rates between 50% and 100% for trout less than 5 grams, (Windmar 1984). Basically, that means that the fish's growth potential is not improved at oxygen levels above 50% of saturation. In other words, its Standard Rate of Oxygen Consumption is constant from 50% to 100% oxygen saturation. If the saturation rate falls below 50%, the standard rate rises. The rise in standard rate of oxygen consumption below the critical oxygen level indicates the increased cost of ventilating the gills when oxygen becomes limiting. FCR rises dramatically and growth slows down until it reaches a stage where there is a 'metabolic' crash and the fish may not survive. For trout of 100 grams, the minimum oxygen threshold is 65-70% of saturation rate. For table size trout, i.e. around 350 grams, the threshold is 70-75%. See Figure 1.

Sensible Precautions

Farmed fish are subjected to a number of stress factors additional to those encountered by their cousins in the wild. It is noticeable that fish in the wild, despite being disposed to and/or are carriers of fish pathogens, very rarely get diseases.

In a rearing environment it is therefore not necessarily wise to operate oxygen regimes close to the fish's critical thresholds, for instance keeping small fish at 50% saturation. Recent research (Caldwell, 1994) shows that oxygen saturation rates both higher and lower than full saturation (100%) will elevate blood cortisol levels in trout subjected to stress. Elevated blood cortisol levels have been implicated in the impairment of the non-specific immune system in fish and other animals. So, in an ideal situation, one should rear trout at 100% oxygen saturation. This is, of course, very difficult in practice and, for salmonid species, one should probably aim at saturation rates above 70-80%. Other fish species, for instance carp, will be happy at lower saturation rates as they have evolved and adapted to a different environment than salmonids.

Feeding Practises

Feed manufacturer's feeding guides will suggest the optimum amount of feed that should be fed for various fish sizes and at given water temperatures. Depending on the energy content of the feed and the size of the fish, the fish will need a certain amount of oxygen to metabolise the feed intake.

The oxygen needs of trout are shown in Table 1 which shows the amount of oxygen needed to metabolise one tonne of feed by various sizes of trout at different temperatures.

Table 1. Kg of oxygen needed to metabolise 1 tonne of feed (23 MJ) at various trout sizes and at different temperatures

Fish size	Water temperature in °C 2	4	6	8	10	12	14	16	18
15-50 gr	347	348	343	343	346	355	372	395	440
50-150 gr	380	382	375	380	379	389	406	433	483
150-400 gr	446	438	420	437	434	450	463	495	551

Table 2. Total oxygen needed for 1,000 kg of trout at different sizes and temperatures when feeding according to feed guide

Temperature	Kg oxygen per 1,000 kg of trout per day 2	4	6	8	10	12	14	16	18
15-50 gr	3.2	3.9	4.6	5.4	6.2	7.1	8.0	8.7	9.2
50-150 gr	2.5	3.1	3.6	4.3	4.9	5.6	6.3	6.9	7.3
150-400 gr	2.1	2.5	2.9	3.5	4.0	4.6	5.1	5.6	5.9

From Table 1 above it can be seen that from 10°C and above, there is an increase in oxygen usage required to metabolise a given amount of feed. This means that, though the fish will eat more and grow faster at higher temperatures, the amount of oxygen needed for a unit of growth is higher.

With the knowledge of how much the trout will eat, as given in a feeding guide, and the amount of oxygen needed per unit of feed, the total amount of oxygen needed for a given population can be calculated.
In Table 2. the total amount of oxygen needed for 1 tonne of trout at different temperatures and sizes is given.

Water requirements for a given standing stock

Trout and salmon smolt farms are mostly located in areas with good water quality. Oxygen saturation rates are high, often around 100% of saturation. Assuming that it is decided not to operate at levels below 70% saturation within the farm, then there will be 30% ‘surplus’ available in the incoming water. The amount of oxygen available in terms of weight (grams, kg etc.) by ‘exhausting’ the water from 100% to 70% saturation will vary with temperature as solubility changes with temperature.

In Table 3. the relationship between oxygen saturation % and concentration at different water temperatures is shown.

Table 3. Available mg/l of oxygen from 100% to 70% saturation at different temperatures

Water Temp	% saturation 100%	70%	available mg/l
4	13.11	9.18	3.93
8	11.84	8.29	3.55
12	10.76	7.53	3.23
16	9.85	6.90	2.95
20	9.08	6.36	2.72

Fed at maximum rates, the theoretical oxygen requirements for 1 tonne of standing stock of trout (50-150 grams) and ‘exhausting’ the water from 100% saturation to 70% will be as follows:

4°C:	3.1 kg/O_2/day	which equals:	9 l/sec
8°C:	4.3 kg/O_2/day	- - -	14 l/sec
12°C:	5.6 kg/O_2/day	- - -	20 l/sec
16°C:	6.9 kg/O_2/day	- - -	27 l/sec

If the trout are only fed at maintenance ration, the water requirements will be 25% of that required when feeding to appetite. In practise, the water requirements are lower than the above shown figures. One reason is that not all the fish in a population will be full of feed and be metabolising at maximum rate at any one time.

As illustrated above, it is basically the amount of feed fed that dictates the farm’s oxygen requirements. If a fish farm has not got sufficient water it will partly suffer a bad feed conversion rate but will also subject the fish to poor health.

AQUACULTURE MEDICINES PART 2

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This article continues the brief overview of the work carried out under the extended programme of research into the difficulties and problems associated with the use of medicines in the aquatic environment that has been ongoing for a good many years at CEFAS Weymouth funded by MAFF/DEFRA Fisheries Division. From time to time brief notes have been published in Trout News explaining some of the more practical aspects of the outcomes of that research. As explained previously, apart from maintaining a watching brief, that programme of research is now largely completed and it was felt that it might be useful to give a brief overview of some of the major achievements.

The rebuilding of the Weymouth laboratory in the early 1990's had meant that during that time efforts had to be concentrated towards the potential for adverse environmental effects and in particular on the risks of transfer of antibiotic resistance beyond the aquaculture environment rather than on experimental work on fish. Opportunity to express and explore the conclusions reached came in the form of invited participation in two international groups. The first was a meeting of GESAMP 31 (Group of Experts on Scientific Aspects of Marine Environmental Protection) funded and organised by FAO and held at the SEAFDEC Aquaculture Division's laboratories near Iloilo in the Philippines in 1996. The second, was an WHO Study Group met in Bangkok in 1997 to consider Food Safety Issues Associated with products from Aquaculture. Both groups resulted in the publication of reports by their sponsoring bodies (below) and much of the documentation prepared for the WHO Study Group was published separately (Alderman and Hastings 1998). These working groups provided a major opportunity to compare and contrast approaches to the use of antimicrobials in aquaculture in the UK and the EU with that in the rapidly growing and relatively unregulated aquaculture industries of S.E. Asia. In the latter, widespread availability and use of antimicrobials may indeed represent a threat to human health from the induction and spread of antimicrobial resistance.

Perhaps more important from the point of view of aquaculture in the UK was the opportunity to produce a briefing document followed by an oral presentation for a working group set up by the Advisory Committee on the Microbial Safety of Food (ACMSF). This working group was set up to consider the risks to humans from antibiotic resistant micro-organisms entering the food chain and the need for any action to protect public health. The briefing document prepared jointly by CEFAS and FRS Aberdeen combined both published and unpublished data and demonstrated that in, the UK at least, the use of antimicrobial agents in aquaculture was limited and well controlled. Indeed it was pointed out that the increasing availability and efficacy of vaccines to control bacterial diseases was already reducing sales of antimicrobials for aquaculture to levels which would make the retention of Marketing Authorisations commercially uneconomic for suppliers. It was pointed out that much of the published data on antimicrobial use in aquaculture concerned extreme worse case conditions (and not from the UK) which were unlikely to re-occur with vaccine availability and better approaches to the use of antimicrobials. If the ACMSF working group had taken the view that antibiotic use in aquaculture presented a significant threat to consumer health availability of such products to control outbreaks of disease could have been severely compromised. Data provided by the CEFAS/FRS brief was quoted extensively in the ACSMF report (ACMSF 1999), with the working group considering that under UK conditions the use of antibiotics was acceptable and did not provide any quantifiable risk to consumers.

During this period the GLP compliant facilities provided by the new Weymouth laboratory were also employed under the Link programme to generate data on the safety and efficacy of the new fungicide Pyceze as part of the programme to gain Marketing Authorisation. With the continuing problems of detection of malachite green residues and metabolite residues in the statutory residues surveillance programme (see Part 1) on farmed fish finally leading to a formal prohibition on its use, a replacement fungicide is urgently needed.

One continuing theme through all work on antimicrobial agents in aquaculture concerns the degree sensitivity of the bacterial pathogens to the drugs used. To define resistant or sensitive strains the minimum inhibitory concentration (MIC) or the minimum bactericidal concentration (MBC) needs to be established. The MIC is the minimum concentration that will inhibit the growth or a micro-organism, the MBC the minimum concentration that will kill it. Although the basic principles of MIC/MBC testing are straightforward the problem has always been that each fish health laboratory use different versions of the basic test methods and interpreted their results in their own way. It could truthfully be said that with the same drug and the same bacterium each fish health laboratory could arrive at a (slightly) different interpretation. As fish health microbiologists a general feeling of unease about this lack of agreement became apparent. Exploration of the state of play in other areas of veterinary and indeed of human medicine showed that this unease was not justified since both in veterinary medicine and human medicine a similar lack of agreed methodology and interpretation existed (and indeed still exists). Together with Peter Smith and Maura Hiney of the Fish Disease

Group at Galway in Ireland and with the help of Patrick Smith of AVL a bid to the European Commission for the funding of a major international workshop to discuss and agree uniform methods of antibiotic sensitivity testing and for the interpretation of those results was put together. The bid was successful and the 4 day workshop was held at Weymouth in November 1999. Fish disease experts from 12 different countries including USA and Canada took part, together with experts in sensitivity testing from human and veterinary medicine. During the workshop draft methods were agreed for all major bacterial pathogens of fish. In addition to a 50 page report of the meeting, the conclusions of the workshop and its proceedings were published in Aquaculture as part of a special edition Annual Review of Fish Diseases (Alderman and Smith, 2001).

The final sector of the programme of work on antimicrobials examined ways in which the use of a few products legally available to aquaculture might be optimised. The standard advice to fish farmers has always been to 'rotate' antibiotics rather than using one until resistance has been produced and then changing. To reduce chances of creating a sub-therapeutic dose situation, therapy should be started as early as possible after the recognition of need, to attempt to ensure that as many fish as possible receive a therapeutic dose and should be continued for the recommended therapeutic period. Early commencement of therapy conflicts with the other 'traditional' advice - namely to wait for the results of antibiotic sensitivity tests before commencing therapy to ensure that the most effective drug is used. A practical investigation of these conflicts was reported by Barker and Page (2000) in Trout News. They showed very clearly that any delay in commencing antibiotic therapy could be disastrous .to gaining control of a disease outbreak. Using a 'predictor' challenge model developed as part of the project it was found that, provided therapy was commenced at 3 days after exposure to furunculosis, even if using lower levels of oxytetracycline than usually recommended, a significant disease outbreak could be controlled. Any delay in commencement of therapy which allowed the outbreak to develop, even where high levels of antibiotics were offered, resulted in failure. From this it is clear that, particularly with established seasonal disease outbreaks, it is critical to commence therapy and not to wait for laboratory tests to recommend a drug of choice.

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STOMACH CONTENTS ANALYSIS OF CORMORANTS AT SOME DIFFERENT FISHERY TYPES IN ENGLAND AND WALES

by Ian Russell, Alastair Cook, Dan Kinsman, Mark Ives and Nicola Lower
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Introduction

The population of cormorants wintering in Britain has increased rapidly over the last 25 years and these birds have extended their range inland from coastal areas and now over-winter and feed in many inland areas. This has increasingly brought them into conflict with inland fisheries.

In England and Wales, cormorants are protected under the Wildlife and Countryside Act 1981, but licences to shoot them can be issued where they are causing serious damage to a fishery. Licences are issued over the winter months when bird numbers are highest at inland sites, and allow limited numbers of birds to be killed in order to reinforce the effects of other scaring methods. It is also a condition of all licences that any shot birds should be recovered and made available for examination.

Methods

Post mortem examination of all shot cormorants is carried out, primarily to enable information to be collected on their diet at different fisheries. The diet analysis for each bird combines:

- Careful identification, enumeration and measurement of intact prey items in a bird’s stomach;
- Cleaning, drying and microscopic examination of the bones and other hard remains (e.g. pharyngeal teeth, otoliths, vertebrae, etc.) that are relatively resistant to digestion, to enable identification and enumeration of other fish present in the stomach;
- Measuring the size of specific ‘key’ prey remains and estimating the length and weight of all fish in each sample using appropriate species-specific regression equations;
- Estimating the proportion of each fish species, by both number and weight, in the diet of birds from different sites.

The results of these stomach analyses are used to assist in assessing the potential impact of cormorants at different fishery sites and as a basis for providing advice and evaluating licence applications.

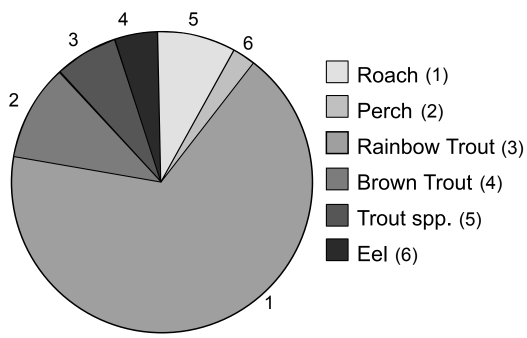
Case studies

Put-and-take trout fisheries

There are numerous put-and-take trout fisheries in England and Wales, some of which are stocked and fished throughout the year, whereas others only operate on a seasonal basis between spring and autumn. Cormorants frequent many of these sites, where the birds are commonly perceived to be having a serious impact upon the introduced trout. In practice, the level of impact on the trout varies considerably, being influenced by factors such as the status of the indigenous fish populations as well as the size and quantities of fish stocked. The following case studies provide two extreme examples of cormorant predation on trout over the winter period, based on data for two sites, one in north-west England that is stocked and fished throughout the year, and another in south-east England which is operated seasonally.

Site 1: Stillwater trout fishery in NW England

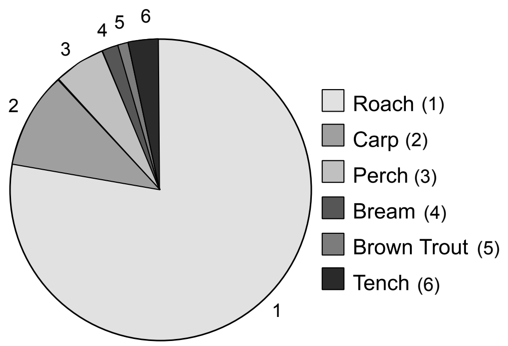
- Diet based on a sample of 48 stomachs containing prey items, from birds shot in the winter months;
- Small roach & perch have been the main prey items by number (75%);
- Trout represent 85% of the diet by weight.



Cormorant diet at a put-and-take trout fishery in NW England - proportion by weight

Site 2: Stillwater trout fishery in SE England

- Diet based on a sample of 25 stomachs containing prey items, from birds shot in the winter months;
- Small cyprinids & perch have been main prey items by number (>99%);
- Trout represent only 1% of the diet by weight.



Cormorant diet at a put-and-take trout fishery in SE England - proportion by weight

Rivers

Within England and Wales, there is substantial variability in the morphology and topography of rivers and this, together with a range of other factors, affects the composition of the fish populations. Cormorant diet appears to reflect this variability.

The histogram below presents the relative proportions (by weight) of different groups of prey species for four different river 'types': a lowland river supporting only coarse fish, a river supporting a mixed salmonid and coarse fishery, and for the upper and lower reaches of two adjacent rivers predominantly regarded as salmonid fisheries. The number of prey species recorded in the samples is included in parentheses. No detailed information is available on fish populations for these rivers, but the species composition is consistent with the expected distribution of species in these catchments.

Conclusions

- The results are consistent with the view that cormorants are opportunist predators that commonly select locally abundant prey species.
- The differences between sites highlight the need for careful evaluation and for the need, where possible, to assess potential impact on a case by case basis.
- Perceived levels of impact upon some commercially valued species (e.g. trout and salmon) can be potentially misleading, at least during the winter period. Coarse fish species can predominate in the diet at sites where this might not be expected. [It should be noted that coarse fish species are also of commercial importance at many sites].

Acknowledgement

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Proportions of prey species (by weight) in the diet of cormorants from riverine sites

EU REVIEW OF FISH HEALTH REGULATIONS

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This article formed a presentation given at the British Trout Farming Conference, Sparsholt in September, 2001

1. Background

The Single European Act of 1987 had the political objective to remove obstacles to trade within the European Community. This included trade in live animals and animal products but it was recognised that animal health protection measures would be required so that increased trade would not lead to spread of serious diseases. The concern about possible spread of fish and shellfish diseases led to the introduction of EC Directive 91/67/EEC in 1991 which established the animal health conditions governing the placing on the market of aquaculture animals and products. Further EC controls for fish diseases were introduced subsequently with Directive 93/53/EEC in 1993 and for shellfish diseases with Directive 95/70/EC in 1995. Under these Directives, various Commission Decisions were subsequently agreed by Member States for specifying the technical requirements in greater detail to ensure a uniformity of standards throughout the EU. Amongst the various measures, two of the most important for the UK were the provision for officially recognising zones and farms to be free of List II diseases (VHS and IHN) and allowing safeguards to protect them from introduction of these diseases by restricting imports of live fish from other Member States to sources in equally approved zones, and the requirement for compulsory eradication of ISA (considered to be exotic to the EU at the time) should any outbreaks occur. From November 1992, GB and Northern Ireland have benefited from 'approved zone' status for VHS and IHN, and the compulsory ISA eradication programme carried out by SEERAD in Scotland since the first cases in 1998 appears to have been very effective at removing this damaging disease from the Scottish salmon farming industry.

In July 1996, the European Commission announced that it planned to begin work on a review of these EU fish and shellfish health rules. The plan was to conduct the work, in the first instance, through a small working group of scientific experts, although the Commission warned of the possibility of delays due to other higher priority work in the veterinary sector. The UK welcomed this initiative. To prepare for negotiations in the future, and to ensure an effective input into proposals for changes to the legislation, Fish II in MAFF (now DEFRA) carried out its own review of the provisions of the Directive and in January 1997 submitted comments and proposals for changes to the Directives of the EU legislation in the light of experience with implementing the various rules over several years and in view of advances in scientific knowledge. Unfortunately, the European Commission's warning of possible delays proved well-founded - there then followed a 3½ year hiatus and it was not until May 2000 that the Commission returned to considering the review.

2. Progress

The work started with a small initial planning meeting of scientific experts and Commission Officials in June 2000 to discuss how to approach the task. The Commission's Health and Consumer Protection Directorate-General (DG SANCO) subsequently announced its intention to review and update all the Community legislation on the animal health aspects of aquatic animals and to set up a working group of experts to provide a sound scientific and technical base for any changes to the rules. An outcome of this was the formation of a larger working group of scientific experts, 1 each from the Community Reference Laboratories for fish diseases and for mollusc diseases and 9 other scientific experts from France, Germany, Ireland, Italy, Netherlands, Norway, Sweden and UK (the two scientific experts from the UK are the author and Ron Stagg of the Marine Laboratory, Aberdeen). DG SANCO then wrote to all 15 EU Member States through their Chief Veterinary Officers inviting comments by early September on the current legislation and any proposals for change. The Commission also wrote to Member States inviting comments and proposals from the Official Services for fisheries and aquaculture. In addition, the Commission decided to seek the views of the aquaculture industry throughout Europe and requested the Advisory Committee of Fisheries and Aquaculture (ACFA) of the Directorate General for Fisheries (DG Fish) to nominate representatives to present industry's views in joint meetings with the scientific experts and Commission Officials. ACFA nominated Nick Yonge (UK) and William Crowe (UK) to represent fish interests and Doug McLeod (UK) to represent the mollusc industry.

Shortly afterwards, a meeting was held between MAFF, SERAD and DARDNI to discuss possible amendments to the legislation from a UK point of view. Scientific aspects of these and other possible technical amendments were later discussed at a meeting of scientists from the Weymouth, Aberdeen and Belfast laboratories. A document proposing changes was prepared by MAFF and sent to the Scottish Aquaculture Health Joint Working Group at the beginning of September for comment as a start to a lengthy consultation process with the UK aquaculture industry. Following further amendments based on the comments received, MAFF submitted the UK's initial views proposals to the European Commission in early September 2000. In November, MAFF and NAWAD held a consultation meeting with representatives of the trout farming and shellfish farming industries in England and Wales and the Fish Veterinary Society to hear their views on proposed amendments and other possible changes to the existing EU rules.

At the first meeting of the EC experts working group in late September, the initial views of the European aquaculture industry were presented by Nick Yonge and William Crowe, representing the Federation of European Aquaculture Producers (FEAP), and Doug McLeod representing the European Mollusc Producers Association (EMPA/AEPM). However, the industry representatives emphasised that these were only preliminary comments and that much more consultation within the industry would be required before formally agreed views could be submitted. These preliminary industry comments were discussed along with the views submitted by Member States in response to the Commission's invitation, and the opinions of the scientific experts on the working group.
The main issues identified from this very preliminary presentation of industry views were:

- Legal controls are essential to prevent disease spread and should include:
- Basic preventative measures (hygiene standards on farms, disinfection of transporters, etc);
- Trade restrictions (unavoidable) on live animals, products, equipment, etc;
- Eradication and outbreak control including contingency plans;

- The range of different aquaculture species and their different diseases need different measures:
- Production levels for different species are changing;
- There are large differences in environmental conditions across the EU;
- The new Directives should be of an enabling nature and not prescriptive, and should allow for regionalisation;

- Financial support is required:
- National and EC funds should be available for eradication
- Private insurance is necessary
- Industry "self-help" funds are needed

The main views of scientific experts in the working group were

- Protection of wild stocks is very important and this includes some diseases of little importance to the aquaculture industry
- It is essential to prevent introduction of new diseases with imports from third countries
- There should be a requirement for registration of all farming establishments and not just those holding susceptible species for the List I and II diseases
- Movement records should be required for all aquaculture operations
- Greater flexibility is needed for diseases covered and the measures to control them, depending on the area of the EU affected. Only diseases of significant socio-economic importance to industry (in any part of the EU) or which threaten wild stocks should be covered
- Processing plants and slaughter houses need to be regulated for aquaculture health protection purposes and not just for food hygiene purposes
- Basic preventative practices (good husbandry/ management) should be a requirement for all farms
- There should be a requirement for notification of unexplained large mortalities and "new" diseases (in EU) for all sectors of the aquaculture industry
- There is need to list the exotic diseases of concern in third countries and for EC inspection services to check the competency of the Official Services of countries claiming to be free or to have zones or farms free of specified diseases.

Commission officials also presented their opinions on the need for change to the legislation, not least that it should be much simpler and more transparent than at present!

Since that first meeting, the full working group considering the fish health aspects has met on four occasions (November 2000, January, March and May 2001) and has started to put together possible constituent parts of a skeleton draft Directive to replace most of the existing legislation on the basis of the views submitted by Member States, the aquaculture industry, and the working group itself. It must be emphasised that these are still at a very early provisional stage and that the views of industry are still being received as more of the different sectors (e.g. turbot producers, sea bass and sea bream producers, eel producers, carp producers, ornamental fish industry, etc, etc) are consulted and give their opinion. Some of the views submitted to date are conflicting and further discussion by the industry across the EU will be needed to try to resolve these differences of opinion.

It is intended that the whole process should be an iterative one, i.e. that the drafts proposals for any new legislation will be submitted to the Member States and representative bodies of the aquaculture industry for their reactions. As a result, further amendments are then likely to be made.

3. Proposals

It is too early to present the detail of the contents of a possible Directive with so much still under consideration and discussion. However, the following list of issues and areas identified for possible inclusion in a new Directive will give some indication of the way the current thinking is going:

Contents/chapters of a possible new Directive for fish and shellfish trade and disease control

I . General provisions (introduction and definitions)
2. General requirements including preventative measures (registration and record keeping)
3. Categories of farms and zones
4. General surveillance requirements
5. Criteria for classification of zones/farms
6. Slaughterhouses and processing plants
7. Measures in the event of suspicion or confirmation
8. Testing and laboratory methods
9. Lists of diseases and susceptible species
10. Conditions for third countries
11. Administration procedures
Annex I Provisional classification of diseases and species.

One of the major issues yet to be decided is the list of diseases and fish species to be covered by the new legislation and expert discussion on this is still underway. As for the fish species to include, the industry view put forward is that there is need for much more flexibility so that different sectors of the fish farming industry are covered by rules more specifically designed for their particular farmed species, also taking account of differences in climatic and environmental conditions between regions of the EU. To assist in considering this, five broad categories of farmed fish species have been provisionally drawn up as follows:

A. Atlantic salmon
B. Other salmonids: rainbow trout, brown trout, arctic char, coregonids (whitefish), hucho hucho (Danube salmon), grayling.
C. Marine fish: turbot, halibut, Dover sole, cod, sea bass, sea bream, drum. D. Coldwater ornamental fish: koi carp, goldfish, golden orfe (ide).
E. Other freshwater fish: eels, cyprinids, catfish, sturgeon, black bass, striped bass, pike, pike-perch

As for the diseases, the expert working group has been considering three possible categories of disease with the following definitions/criteria:

(i) List I
Potential for significant economic impact, rare or exotic, eradicatable, potential for rapid spread, requires compensation for eradication measures.

(ii) List II
Should meet a significant number of the following criteria:

(i) The disease causes, or has potential to cause, significant losses at a regional level (annual costs associated with the disease and its control may exceed 5% of the value of the production of the susceptible fish species in the region).
(ii) There is a reliable and simple test for infected animals. The tests must be specific and sensitive and the testing method should be harmonised at EU level.
(iii) The disease is difficult to control and contain at farm level without stringent bio-security measures.
(iv) Experience has shown that disease-free zones and farms can be established and maintained.
(v) Disease control at regional level is cost beneficial.
(vi) The disease has detrimental impact on the wild fish populations and/or wild fish used for stock enhancement.

At least, criteria nos. (i) or (vi) and (iii), (iv) and (v) must be fulfilled.

(iii) Other diseases
Exotic or rare in the EU, notifiable to the OIE and having significant economic or ecological impact elsewhere in the world. Significance to the EU unclear because of uncertainty about host susceptibility or the sector of aquaculture industry at risk is currently small.

Agreement has yet to be reached on which particular diseases should fall into each category and whether the current List II and List III disease lists should be combined into a single List II. However, discussion of the other important issue of notification or reporting of cases of important diseases has led to the following provisional proposals:

1. Immediately notifiable/reportable diseases:

Oncorhynchus masou virus (OMV) Epizootic haematopoietic necrosis (EHN)
Epizootic ulcerative syndrome (EUS)
Red sea bream iridoviral disease (RSBIV)
White sturgeon iridoviral disease (WSIV)
List I diseases of the EU (ISA)
List II diseases of the EU in approved zones and farms
Important emerging diseases
(Rare, not exotic)*

2. Annually notifiable/reportable diseases:

List II diseases in non-approved zones and farms (to include current List III diseases ?)
List III diseases ?

However, it must be emphasised that more discussion amongst the experts will have to take place before the disease lists are finalised.

The author had hoped that more details of the new provisions would have been agreed by the time of this conference, but unfortunately delay due to higher priority being given by the European Commission to other legislation requirements, has meant that progress on developing the new rules for fish and shellfish trade and disease control has slowed down. If activity on developing the new legislation increases it is possible that a draft Directive may be ready for scrutiny and comments sometime in 2002. However, there will then be a lengthy process of Member States giving their formal views through meetings of Commission working groups of national representatives and the Standing Veterinary Committee, at which it can be expected there will be some differences of opinion. Lengthy negotiation will no doubt have to take place before the proposed new legislation is put to the Council of Ministers for final agreement. It is the intention of DEFRA, NAWAD, SEERAD and DARDNI to consult their respective sectors of the UK aquaculture industry on all stages of development of the new legislation and to take their views into account.

ENVIRONMENTAL REQUIREMENTS OF SEA TROUT AND SALMON

by Alan M. Walker and Mike Pawson, CEFAS Lowestoft Laboratory, Lowestoft NR33 0HT

Introduction

Sea trout stocks in parts of Scotland and Ireland crashed in the late 1980s and have since shown little or no recovery. Though sea trout catches in England and Wales also declined during this period, they have subsequently improved, and most sea trout stocks in England and Wales are currently considered to be in a healthy state (Salmon and Freshwater Fisheries Review). These contrasting situations highlight our lack of understanding of the factors that impact on sea trout stocks, which are an important species for anglers and in terms of biodiversity.

CEFAS is engaged in a 5-year National Sea Trout Research Programme (funded by DEFRA) to investigate the factors that may be associated with the distributions and abundance of sea trout and salmon in river systems in England and Wales. The purpose of this research is to provide information as a basis for advice to UK and international bodies regarding the status and conservation of sea trout and salmon populations in England and Wales. Part of this research programme is a comparative study of the habitat uses of adult sea trout and salmon as they migrate upriver to spawn.

Study Site

An extensive review of candidate study rivers throughout England and Wales revealed that the River Kent, Cumbria, was the most appropriate study river. It has healthy stocks of both sea trout and salmon, sea trout of a size comparable with salmon are available, and the river contains a variety of riverine habitats within a relatively short catchment. Following a meeting on the evening of 16 May in Kendal with representatives of local fishery trusts, angling associations, riparian owners, conservation bodies and other interested parties, it was agreed that the River Kent and its tributaries would be used as the prime study site for the Habitat Use programme.

Automatic listening receiver

Study Programme

Unlike previous tracking studies, the main aim of this programme is to study the characteristics of the areas of the river where salmon and sea trout rest during their upstream migration. The plan is to capture adult sea trout and salmon in the lower reaches of the River Kent in June/July, and to tag these fish with small, individually identifiable, radio transmitters. Some two-thirds of those released will also carry a Data Storage Tag, to record water temperature experienced by the fish. The subsequent locations of these fish will be monitored by automatic listening receivers (ALS) sited appropriately throughout the catchment, and by periods of active tracking using hand-held aerials. The ALS will be used to confirm the presence of each fish in a specific reach of the river, and the active tracking will locate the exact position in which they are lying so that we can identify the habitats used and their small-scale movements (10s of metres) in relation to river flow etc. Environmental parameters (e.g. depth, water temperature and dissolved oxygen concentration) will be measured in and around the positons where these fish rest during their upstream migration.

Tracking using hand-held aerial

Release of tagged fish at capture site

The tracking and habitat survey schedule involves six study periods, two weeks in June and one week in each susccessive month until November, and the last two field visits will be timed to recover tagged fish which have spawned. The first field trip took place from 8 to 22 June, when we set out and range tested the array of listening stations within the Kent catchment. A total of three sea trout and three salmon were tagged during this visit; one sea trout caught by EA staff in the fish pass at Force Falls, and two sea trout and three salmon donated by anglers fishing waters between Force falls and Levens Park. All fish were tagged and released at the site of capture.

Details of the research programme have been added to the CEFAS website (www.cefas.co.uk), and these will be updated each month during the study period to show our progress with tagging fish and their upstream movements. Posters advising anglers what to do if they catch a tagged fish have been placed at strategic points around the catchment and flyers placed with local licence and tackle outlets. A summary of the results from the first year's work in this two-year study will be reported in the January 2003 edition of Trout News.

FISH HEALTH CONTROLS: THE ACTIVITIES OF THE FISH HEALTH INSPECTORATE IN ENGLAND AND WALES 2001

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

Introduction

The work of the Fish Health Inspectorate at CEFAS Weymouth from the advent of the Single Market in 1993 has been documented annually in Trout News since 1996.

This report aims to provide an update of the Inspectorate's work during 2001, 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 makes no mention 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 were greatly disrupted by the Foot and Mouth Disease (FMD) outbreak, which prevented Fish Health Inspectors gaining access to broad areas of the country through much of the spring and summer periods, except to deal with reported disease outbreaks. Much of the spring programme had to be re-scheduled, and only the minimum number of farm inspections was carried out, (at sites holding salmonid broodstock), to satisfy the requirements of the EU fish health regime.

The bulk of the salmonid farm inspection programme, including second visits to broodstock sites, was completed in the autumn, once FMD restrictions had been lifted. Second inspections on some egg import sites had to be cancelled. Samples for VHS and IHN testing were as usual targeted from 50% of the farms visited. This modified inspection programme was completed as scheduled, and ensured that the requirements of the EU fish heath regime were met.

Table 1. Number of tasks, by category, undertaken by the Fish Health Inspectorate in 2001

	Site type		
	Salmonid	Coarse	Total
Farm inspections (no samples)	213	156	369
Routine sampling and inspection	155	2	157
Inspection and sampling on suspicion	1	3	4
Notifiable disease re-tests and contact tests	9	6	15
Reported disease outbreaks & mortality investigations	18	116	134
Import checks: Sampling	19	53	72
Inspection/physical checks	18	34	52
Export certification	6	109	115
Farm registration visits	4	12	16
Site disinfection visits	2	1	3
Wild fish monitoring	6	0	6
Other visits/inspections	89	0	89
		Total	1,032

The import-monitoring programme for salmonids was also somewhat curtailed, but random samples of juvenile fish derived from each source of egg imports from each exporting country, i.e. Denmark, Isle of Man, N Ireland and South Africa were sampled wherever possible. These samples were taken when the imported stock were at approximately the six weeks' feeding stage, when any serious disease problems were likely to be manifest.

Inspectors were required to take samples on suspicion of the presence of a notifiable disease during only 1 salmonid farm inspection in 2001. The direct reporting of disease problems by fish farmers instigated inspections on a further 9 farms during the year. In addition, samples were taken from 9 mortalities in wild salmonid fish populations. These figures are very similar to those for the previous year, but represent a significant decrease in the number of disease investigation relative to the preceding five years. None of the investigations in 2001 resulted in the diagnosis of a notifiable disease.

Notable among the mortality investigations was the re-emergence of lactococcosis at the farm first found infected in 2000. This new outbreak resulted in the closure of farming operations at this site.

The inspection programme for coarse fish sites during 2001 involved a single visit to each farm site, to look for evidence of mortalities and to check movement, mortality and medicine records. The formal programme of import checks on consignments of SVC susceptible species coming from non-EU countries was increased during the year as the FMD restrictions meant that Inspectors had both the time during the spring trade peak, and free access to the main airports to conduct this work. As a result a total of eighty-eight consignments were inspected/sampled from all of the main countries supplying these fish. All tests proved negative for SVC.

The Inspectorate also investigated 120 mortality events in coarse fishery waters and sites holding coldwater ornamental fish during the year.

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 problems on suspicion samples were taken on suspicion of either of these diseases.

BKD. There were no new cases of BKD identified in 2001, and only 5 sites remain designated for the disease. One site undertook a clearance and disinfection during the latter part of the year, with a view to lifting controls early in 2002. Two of the sites are fallow.

Two of the previously infected farms completed their three years of negative testing, while a third site was re-developed, and undertook a total clearance and disinfection late in the year. The Designated Area Orders on these sites were lifted early in 2002.

Re-test samples on 3 remaining active, infected trout farms led to the re-isolation of *Renibacterium salmoninarum,* the causative agent, from 2 farms. One of these farms still held infected stock from the time the disease was first isolated in 1999, while the second site has tested positive in each of the previous 6 years.

Of the remaining 2 sites designated for BKD, one has been entirely dismantled, and another remains fallow and has been partially disinfected. It is hoped that the designations on these sites can be lifted, following tests on local feral fish populations and completion of disinfection respectively.

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

Table 2. Imports and exports of fish monitored by the inspectorate in 2001

A.	**Import licences by category for trade from non-EU countries**		
	Tropical species (annual licence)		178
	Koi & goldfish (annual licence)		167
	Specified purpose (Indiviual consignment)		197
	Human consumption		74
		Total	616
B.	**Movement documents for EU trade**		
	Import documents received/checked		
	Salmonid eggs		109
	Turbot (for direct consumption)		118
	Coarse fish		91
	Shellfish		52
	Others		168
		Total	538
C.	**Export documents issued**		
	Salmonids		5
	Ornamental fish		134
	Other fish		11
	Shellfish		74
		Total	224

variety of other Gyrodactylus species were found, but never at problematic levels.

SVC. Re-testing for SVC took place on 4 infected sites in 2001, all tested negative for the disease.

Two linked sites, one garden pond and an aquarium supply site tested positive for Spring Viraemia of Carp (SVC) during the year. Molecular biological investigations showed that this SVC strain had not previously been seen in Britain, and suggested that it may have originated in fish imports from the Far East. We were not however able to confirm the actual source of this outbreak.

Emergent diseases

***Lactococcus garvieae* investigations.** Following the first occurrence of fish mortalities associated with the presence of the organism *Lactococcus garvieae*, in September 2000 in an English fish farm, there was a repeat outbreak at the same location in 2001. As a consequence the parent company chose to cease fish farming at this location, at least for the foreseeable future.

Koi Herpes Virus (KHV). Following reports of significant mortalities in ornamental koi carp, CEFAS were able to identify the presence of KHV associated with some of these mortalities. These were the first confirmed cases of the disease, though it is likely that the causative virus had been present in the country for a number of years following its first documented occurrence in koi in Israel. The disease appears to be restricted to *Cyprinus carpio,* in which it can cause very high mortalities at water temperatures above 21°C. Detection of infection is extremely difficult, as like other herpes viruses, KHV can exist in a latent state in the fish, which conventional tests will not detect.
The disease is considered to be a major problem to the coldwater ornamental fish trade, and may pose some threat to coarse fishery waters. CEFAS is working to gain a greater understanding of the disease and its diagnosis, in order to provide support to the industry and fully assess the threat from and potential sources of this disease.

Import/export trade

As ever, there was a significant demand for licences to import fish from countries outside the EU. A total of 591 licences were issued. While this was a significant decrease over 2000, due to changes in koi and goldfish licensing rules from the Beijing region of China, it represents a slight increase over previous years. 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 and turbot for direct consumption, as in 1999 and 2000.

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

The illegal import of coarse fish for introduction to fishery waters remains a significant problem. During 2001 the Inspectorate also intercepted a large illegal consignment of ornamental carp, which originated in Italy. The importer was successfully prosecuted, and in addition to the loss of the stock which were valued at around £30,000, he had to pay fines and costs of a further £30,000. It is hoped that with the imposition of such penalties, by the courts, the temptation to illegally import fish will be lessened significantly. With increasing support from the carp fishing industry, which in parts has started to recognise the threat posed by illegal imports, we hope to make further impact on the illegal trade in the coming year.

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.

INFORMATION FILE

IN MEMORY OF DAVID McGREGOR

29 November 1944 – 23 May 2002

David McGregor, a Senior Fish Health Inspector at Weymouth, died recently following a six-month battle against leukaemia. A close friend and colleague of mine throughout the twenty five years we worked together at the laboratory, David is sadly missed by all of us who knew him, and our deepest sympathy goes to his wife Sheila and family.

More than two hundred friends and colleagues from across the country attended the funeral service in Weymouth, and it was clear from the many expressions of sadness and loss just how much David was loved and respected. He was a likeable man, enthusiastic, vigorous and humorous - a man dedicated to his family, friends and work. He was someone who would always be there for you, whether on a professional or personal level. Many of those attending the funeral recalled the contribution David had made to the local community through boards of school governors, scouting and, not least, through the annual Upwey pantomime in which he always enjoyed a major role.

David completed his degree in zoology at Aberdeen University in 1967 before beginning a career in aquaculture and fish health with Unilever at their research laboratory in Aberdeen. His work concentrated on fish pathologies associated with a variety of aquaculture species. In 1970 he made a move with a fellow Unilever colleague David Conroy to establish a fish pathology unit at the Royal Zoological Society under Dr Ian Keymer the Society's chief pathologist based at the London Zoo. During his time at the zoo David's initial studies concentrated on *Vibrio anguillarum* its culture, characterisation and pathogenicity to both marine and freshwater fish. He also provided a disease diagnosis and treatment advice service to the London Zoo aquarium and often acted as the Society's adviser on fish related problems.

From 1973 his studies switched to research into the phagocytic mechanism in turbot in response to challenge with inert material and microorganisms, and David was awarded his M.phil. based on this work.

Having commuted into London for seven years from a home in Reading, and just started a family David took the opportunity to move to rural Dorset in 1977. He joined staff at the Fish Disease Laboratory (FDL) Weymouth, then part of MAFF, to further develop his fish pathology expertise and investigate disease problems in the developing fish farming industry. The small group established at around this time in Weymouth evolved into the Fish Health Inspectorate (FHI) that is now responsible for the implementation of the UK governments statutory responsibilities for fish and shellfish health in England and Wales.

During the twenty-five years as a Senior Fish Health Inspector David retained a close contact with the developing aquaculture industry and the associated emergent disease problems that inevitably mirrored this development. Always willing to listen, analyse, and wherever possible offer a positive perspective on a problem, David provided a valuable service particularly to newcomers to the industry in the late 1970s and 1980s when the industry was expanding in both size and number. With the advent of the single market in 1993 the FHI was charged with ensuring that the fish health monitoring programmes met the requirements of the EU regime, establishing and maintaining our approved zone status providing a safe environment in which the aquaculture industry could continue to develop. David played a leading role in this development, training and mentoring the expanding FHI team and leading on the underlying science of the programmes. David has always remained very generous with his accumulated knowledge and through various publications, courses and seminar programmes and his obvious enthusiasm for his subject has I am sure encouraged many to follow in his footsteps.

David has also had close ties to the Isle of Man and since the mid seventies was responsible for providing advice, and delivering a fish health monitoring programme for the IOM in conjunction with the IOM government. This was initially to meet UK ova import requirements and allow trout ova to be imported into UK but latterly to meet the EU approved zone standards and permit trade throughout Europe. I know David looked forward to his regular trips to the IOM come rain or shine, and in recent weeks it has become clear just how much colleagues on the IOM felt the same.

More recently David had a potentially expanding role in developing elements of CEFAS business, with participation overseas at various fora and acting as a consultant, troubleshooting fish disease problems.

David's obvious enthusiasm for his work and business enterprise has always been contagious and both colleagues at Weymouth and those in the aquaculture industry have benefited from his eagerness to help in whatever way possible. At his funeral I met some of David's non-work related friends from Weymouth, Reading and farther afield and was pleased to hear how they all also felt that David had been a very positive influence in their lives, always full of ideas and enthusiasm. His knowledge built up over the years in Aberdeen, London and latterly over twenty-five years based in Weymouth and his zest for life will be greatly missed by all that new him.

Eric B Hudson
June 2002

THE FISH HEALTH INSPECTORATE & YOU

STANDARDS OF SERVICE – CITIZEN'S CHARTER PERFORMANCE RESULTS

by 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 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.

Our web site dedicated to the movement and keeping of fish – www.efishbusiness.com has been available for over a year, an increasing number of callers have been directed to this site 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 2001 to 31st March 2002.

	Achieved in 2001-02
Correspondence	
The Inspectorate's target is to reply to all letters, e-mails, faxes and complaints, within 10 working days of receipt.	**93.8%**
Import licence applications	
The Inspectorate has undertaken to issue import licences within 10 working days of receipt.	**99.7%**
Deposit licence applications	
The FHI issue crayfish, 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.	**70.6%**
Registration administration The Inspectorate aim to complete the administrative action within a further 10 days from the date of the visit.	**93.1%**
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.	**78.2%**
Overall results	
The overall compliance rate with our set targets.	**89.9%**

The total amount of correspondence received and recorded by the Inspectorate was 2022. Our performance fully met or approached our targets in most areas. We will continue to strive to achieve all our standards in 2002/2003.

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.

TRADE IN LIVE AQUATIC ANIMALS IN SCOTLAND

Fisheries Research Services of the Marine Laboratory, Aberdeen have produced the first report listing animal statistics for international trade (imports and exports) in live aquatic animals in Scotland over the period 1993 – 2001. The report is divided into 4 sections, corresponding to the end use of the products. Section 1 covers trade in aquaculture and re-stocking and is, therefore, largely concerned with salmonids, but includes species new to aquaculture such as cod, turbot and halibut as well as shellfish. Section 2 is concerned with trade associated with human consumption, listing species imported under licence or regulatory control. Data on exports are imprecise because of the lack of requirements to record export data. Section 3 covers trade associated with research-related work (aquaculture, pure research and bioassay) and lists 36 fish species and 16 non-fish species imported and a total of 15 species exported. Section 4 deals with trade in ornamental and tropical species mostly originating from the Americas and the Far East. There is no requirement to specify numbers or specific names and hence accurate information on imports is not available but estimates are given.

The report also provides a brief analysis and assessment of future international trade within the 4 fields and concludes with a reminder to maintain strict import controls on all species to prevent disease. To this end information on GB import licence requirements and legislation governing imports are appended to the report.

Copies of the report, which was published in January, 2002, are available from:

Fisheries Research Services, Marine Laboratory,
PO Box 101, 375 Victoria Road, Aberdeen, AB11, 9DB.
Tel: 1224 876544. E-mail: enquiries@marlalb.ac.uk

OUTBREAK OF SPRING VIRAEMIA OF CARP IN TYNE AND WEAR

The Department for Environment, Food and Rural Affairs (DEFRA) has issued an Order prohibiting the movement of fish to and from Mount Pleasant Lake, Tyne and Wear, following an outbreak of a contagious viral disease in common carp.

The outbreak of Spring Viraemia of Carp (SVC) in the lake has no implications for human health, but SVC is a serious viral disease which can kill common and ornamental carp as well as a variety of other species including tench, roach, rudd, goldfish, pike and Wels catfish.

Fish Health Inspectors are investigating the source of the outbreak and tracing any fish that may have been in contact with fish at the infected site.

The Order was issued on 30 May after laboratory tests confirmed the presence of SVC, a notifiable disease under the Diseases of Fish Act 1937. Before the Order can be lifted, the site must test negative for SVC for three consecutive years. Alternatively, the Order could be lifted sooner if the infected site underwent an approved clearance and disinfection programme.

The clinical signs of SVC can include darkening of the skin, swollen eyes, abdominal swelling, pale gills, trailing faecal casts and protrusion of the anus. Infected fish may be lethargic and show areas of bleeding in the gills and skin.

Anyone noting deaths of carp or any other species susceptible to SVC, should immediately contact the Centre for Environment, Fisheries and Aquaculture Science (CEFAS), Weymouth Laboratory.

Anyone who imports, keeps or retails carp or other susceptible fish should take strict precautions to prevent the spread of SVC and follow the advice set out in DEFRA's advisory booklet 'Combating Fish Disease' copies of which are available on the DEFRA website www.defra.gov.uk/fish/fishfarm/index.htm or free from CEFAS, Fish Health Inspectorate, Weymouth Laboratory, The Nothe, Barrack Road, Weymouth, Dorset DT4 8UB. Tel: 01305 206673/74 Fax: 01305 206602, Email: fish.health.inspectorate@cefas.co.uk. Further information can also be found at www.efishbusiness.co.uk

USE OF MALACHITE GREEN ENDED

The Department for Environment, Food and Rural issued a News Release on 11 June announcing the end of the use of malachite green as a fungal treatment in farmed fish. The full text of the News Release is reproduced below for information. Similar announcements have been made by the Scottish Executive Environment and Rural Affairs Department and the Northern Ireland Assembly Department of Agriculture and Rural Development.

DEFRA
Department for
Environment,
Food & **Rural Affairs**

NEWS RELEASE

Nobel House, 17 Smith Square, London, SW1P 3JR
Tel: 020 7238 1133/1134/1128 Fax: 020 7238 5502/5506/5529/6134
Out of Hours Tel: 020 7270 8960 Out of Hours Fax: 020 7270 8125
website: www.defra.gov.uk

219/02 11 June 2002

USE OF MALACHITE GREEN TO END

The use of a common fungal treatment in fish farming is to end following discussions between the UK and the European Commission. Fish farmers are co-operating fully with the Government to stop the use of the product with immediate effect.

Malachite green has been used extensively by the aquaculture industries in Europe and throughout the world for many years in the absence of any authorised veterinary medicine alternative. It has proved particularly effective at protecting the welfare of farmed fish. The UK Government has taken scientific advice from independent advisory committees over the past eight years on the use of this product to ensure that the interests and health of consumers are protected. However, there are continuing concerns about its potential effect on human health.

A veterinary medicine alternative to malachite green called "Pyceze" has now been developed in the UK with the assistance of funding from the salmon and trout industries and DEFRA. The active ingredient of this new product, "bronopol," was permitted by the EU for use in the treatment of fish for the first time last year. The Veterinary Medicines Directorate has granted a provisional marketing authorisation for Pyceze and they are currently assessing the suitability of the product for full marketing authorisation. In the meantime Pyceze is available for the treatment of fish and their ova under veterinary prescription.

The European Commission is being kept fully informed of the arrangements for withdrawing use of malachite green in the UK. The Commission is also considering the situation in other member states and in countries exporting farmed fish into the EU.

Notes for Editors

1. European Commission concerns about the continued use of malachite green in salmon and trout farming in the UK were raised following a recent inspection by the Commission's Food and Veterinary Office to evaluate controls on residues in live animals and live animal products.

2. Malachite green is not listed as a veterinary medicine under Annexes I, II or II of Council Regulation 2377/90, and its administration for that purpose is therefore not permitted in aquaculture. However, in the absence of any effective alternative treatment for fungal infections in fish, its use has continued in the UK on the basis of surveillance screening to prevent residues likely to prove harmful to human health in the final product.

3. Information about the consideration which the independent advisory Committees (the Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (COT), the Committee on Mutagenicity of Chemicals in Food, Consumer Product and the Environment (COM), and the Food Advisory Committee) have given on the use of malachite green may be obtained from the Food Standards Agency.

4. Information on the safety of farmed salmon and trout for human consumption may also be obtained from the Food Standards Agency (Tel no: 020 7276 8888).

5. Pyceze is manufactured in the UK by Novartis Animal Vaccines Limited, 4 Warner Drive, Springwood Industrial Estate, Rayne Road, Braintree Essex (Tel no; 01376 551222).

Press Enquiries: 0207 238 6094
Public Enquiries: 08459 335577
Press Notices available via DEFRA website
http://www.defra.gov.uk

BRITISH TROUT FARMING CONFERENCE, SPARSHOLT 2002

Wednesday 4th, Thursday 5th and Friday 6th September 2002

PROGRAMME

Wednesday 4th September

	Delegates gather
from 1900	Trouw Barbecue

Thursday 5th September

0900-1000	Registration
Chair:	Niall Bromage, University of Stirling
1005-1015	Welcome and Opening Address Tim Jackson, Principal, Sparsholt College Hampshire
1015-1040	Ozonization Uwe Waller, Marine Oekologie, Institut fuer Meereskunde
1040-1045	Discussion
1045-1110	Recirculation: the practical application Bent Hojgaard, BH Consult APS
1110-1115	Discussion
1115-1145	Coffee
1145-1210	Raw materials in fish feeds John Williamson, Trouw Aquaculture
1210-1215	Discussion
1215-1240	Feeding systems: an independent review Sunil Kadri: Aquaculture Innovation
1240-1245	Discussion
1245-1400	Lunch
Chair:	Robin Scott, Nidderdale Trout Farm
1400-1425	The Peters Farm Principle/veal production - Lessons for Trout? Alfred Boeve, Alpuro Group
1425-1430	Discussion
1430-1455	Nautilus: socio-economic survey Kath Winnard, Nautilus Consultants
1455-1500	Discussion
1500-1545	Tea
1545-1610	Hammond: broader promotional picture Suzanna Hammond, Hammond Communications Limited
1610-1615	Discussion
1615 onwards	BTA Annual General Meeting - Norman Theatre
1900	AVL Reception
1930	Conference Dinner

Friday 6th September

0900-0945	Registration and Coffee
Chair:	Nick Read, Alderley Trout Farm
0945-1030	French/Italian producers: what are they doing to do it right? Yves Moutounet, Biomar
1030-1035	Discussion
1135-1100	Waste disposal: legislatative and methodology review Barney Kay, National Farmers' Union
1100-1105	Discussion
1105-1135	Coffee
Chair:	Trevor Whyatt, Allenbrook Trout Farm
1135-1200	The EA Trout Strategy Guy Mawle, The Environment Agency
1200-1205	Discussion
1205-1230	Angler Survey/how to attract anglers/the future of re-stocked fisheries Paul Knight, Salmon and Trout Association
1230-1235	Discussion
1235-1330	Lunch
Chair:	Rob Hughes, Trouw Aquaculture
1330-1355	RTFS Sandra Adams, Institute of Aquaculture, University of Stirling
1355-1400	Discussion
1400-1425	Argulus Nick Taylor, Institute of Aquaculture, University of Stirling
1425-1430	Discussion
1430-1500	Total Health Care Chris Gould, Aquaculture Vaccines Limited
1500-1505	Discussion
1505	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

BTA NEWS

Jane Davis, Executive Officer, British Trout Association,

FEAP

The Federation of European Aquaculture Producers (FEAP), of which BTA is a member, represents Aquacultural producer organisations and associations across Europe, who in turn represent a broad spectrum of freshwater and marine species producers. The Federation acts on behalf of its' members in dialogue and consultation with EC regulating bodies and promotes awareness of the benefits of Aquaculture to a world wide audience.

Aqua-media, a web site developed and part funded by FEAP has recently been launched. Aqua-media is accessible in all major European languages and seeks to promote the benefits & realities of aquaculture and its' potential to legislators, interested parties and the public at large. Each member organisation can post relevant production, promotional or educational information on the site in sections that are specifically devoted to their production. Aqua-media also provides FAQ's, addresses responses regarding environmental and sustainability concerns of the general public and holds numerous recipes and photography for consumers and the media. Take a look at www.aqua-media.org

Co-operation and networking are essential for individual associations as they facilitate access to expertise and industry knowledge. FEAP provides a forum where diverse issues such as, EU consolidation of licenced theraputants to increase the availability of authorized products and EU disease prevention measures that institute movement controls across zones are debated and agreed.

FEAP Database

FEAP also devised the FEAP database. The database collates data using forms that are sent to UK trout producers each month, and which request sales and biomass data for rainbow trout. This database has been in operation for a number of years, albeit with varying support from the industry. The database allows FEAP the opportunity to gather accurate production statistics for each aquacultural species produced across Europe. These production statistics, which can be accessed via FEAP's website www.feap.org, are a valuable tool for the Federation for demonstrating the strength of its representation, for estimating future and current production trends and for its' members in evaluating their industry's relative national position.

The benefit to contributors is also convincing. Monthly biomass and sales data collated from UK contributors and, a recent addition, extrapolated industry statistics presented graphically are distributed each month to participants. Fish feed sales updates, make available to the BTA by Fish Feed Manufactures, are now also included in information returned to contributors.

Current participants represent some 7,000 - 10,000 tonnes of annual rainbow trout production. Ideally, BTA would like the support of the entire UK industry. All data sent to the BTA is confidential, and is seen by BTA staff only – no one else has access and only collated information is sent to contributors and FEAP. The data form can be emailed, faxed or posted at your convenience. All UK producers are eligible to contribute and receive monthly results, regardless of whether they are BTA members.

Please – when you next receive your FEAP form consider the benefits contributing would bring to your business and to the industry at large.

PROFET

FEAP are currently planning a series of European workshops on research requirements and networking for professional aquaculture, called PROFET. It is intended that the PROFET workshops will act as a forum for debate on RTD issues affecting professional aquaculture in Europe. Through 6 separate workshops, organised over an 18-month period, a focus will be provided on species and topic-specific issues in order to identify the research needs of the European SME aquaculture sector. An integral part of these workshops will be the promotion of existing networks for the dissemination of EU research results and technological transfer. It is expected that participants will be primarily, representatives of the production sector, but with significant intake from the academic sector and thematic network operators.

The workshops will seek to achieve the following targets:

- Be producer-orientated, identifying research *and* technology needs for species, topics or geographic regions.
- Provide information exchanges between those active in the subject under discussion
- Familiarise the producers with the activities of the networks, EU RED policies and trends and RTD support mechanisms (particularly those concerning SMEs)
- Foster new inter-professional contacts.
- Provide guidelines, from the European professional aquaculture sector, as to the desired direction of European RTD policy and promote the opportunities for sustainable networking.

It is anticipated that trout will be split into two workshops: North and South. The Northern workshop hopes to attract attendees from Denmark, Sweden, France, Norway, UK, Germany, Poland, Belgium, Ireland and Iceland. While the Southern workshop will cover France, Italy, Spain, Greece and Turkey.

Funding for the PROFET workshops has been secured from EU funds and associated industry bodies, however attendees will be required to pay delegate fees. Under these financial conditions the workshops can only be held if sufficient numbers are confirmed. All producers are welcome to send delegates, if you are interested in sending delegates or would like to attend yourself please contact the BTA office to register your interest.

WHERE TO GET HELP OR 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

LINK Aquaculture
Dr Mark James, Marine Resource Consultants Ltd,
c/o Freshwater Fisheries Laboratory
Faskally, Pitlochry, Perthshire PH16 5LB
(Tel. 01796 472060) (Fax. 01796 473523)
www.linkaquaculture.co.uk

DEFRA/BTA FUNDED RESEARCH

LINK AQUACULTURE – TROUT RELATED R & D

Compiled by Dr Mark James, LINK Aquaculture Co-ordinator

As the LINK Aquaculture Programme draws to a close I thought it would be appropriate to briefly sum up what has been achieved in our Trout related R&D projects and take a personal overview of the future prospects for aquaculture research in the UK.

The development of an alternative to Malachite Green, project (TRT01) was responsible for the discovery of Bronopol, as the active compound in the product Pyceze. This was an excellent project conducted by a highly professional, multidisciplinary team, which finished in 1998. It has now taken three and a half years and significant investment on the part of the pharmaceutical companies involved to reach the stage of seeking a full product licence. Given that Bronopol was selected on that basis that it was already in widespread use in other household products, this time scale serves as a stark reminder of the formidable regulatory hurdles that must be overcome to take an aquaculture medicine to market.

Despite these risks and difficulties, Aquaculture Vaccines Limited (AVL) have invested in a number of LINK Aquaculture projects, ranging from the search for effective chemical treatments for Pancreatic Kidney Disease PKD (project TRT04) and Whitespot (project TRT06), to vaccine development for Bacterial Kidney Disease (BKD) (project SAL10).

After some encouraging results, the identification of two candidate PKD treatments and an extension, the project team did not succeed. Regrettably, the active compounds were toxic to the fish, when used at doses that reliably killed the disease agent responsible for PKD. The enthusiasm and commitment of the industrial partners in this project was remarkable and bodes well for future collaborative work in this field. Two promising chemical treatments for Whitespot have also been identified and additional funding is now required to take forward field trials.

Vaccination is seen as the ultimate goal in terms of disease prevention. When LINK began, many vaccine related proposals covered every aspect of development, including the possibility of DNA vaccination. At present, most vaccines consist of whole preparations of the infective agents (bacteria or viruses), either killed or inactivated in some way so that they elicit a protective immune response in the fish. More recently, molecular reccombinant technology has been used to identify, isolate and synthesise the parts (antigens) of the infective agent that elicit an immune response. In simple terms, the DNA that codes for the antigen is introduced into a suitable yeast or bacteria, which than acts as a living production factory for the antigenic molecules to be used in the vaccine. Recombinant technology is now generally accepted by the regulatory authorities and can be a highly efficient and cost effective method of vaccine production. Due to a combination of technical and regulatory constraints, development of DNA vaccines for aquaculture species has largely been abandoned, although if its promise is realised in other sectors, this technology could be an important step forward in disease prevention and management.

Using recombinant techniques, a number of potential vaccine antigens for BKD were identified. The industrial partners AVL, have conducted additional field trials that look very promising and it is anticipated that progress towards a commercially available vaccine will continue. As a result of this, and similar projects in other sectors, there has been a welcome exchange of techniques and scientific disciplines between the research community and the pharmaceutical industry. Researchers have become aware of the need to produce experimental results that will ultimately be admissible to the regulatory authorities as part of the licencing process. Pharmaceutical companies have discovered the advantages of collaborative research for developing disease test models and field trials.

For every success in this field there are, however, a number of failures. A highly productive research team at the Institute of Aquaculture has recently completed a project to develop a vaccine for Rainbow Trout Fry Syndrome (RTFS) (project TRT10). The bacterium that causes this disease (*Flavobacterium psychrophilum*) is problematic to work with. It is difficult to both isolate in the field and culture in the laboratory. Attempts to infect fish in the laboratory to conduct vaccine trials have also been unreliable. That said, the research team made considerable progress in isolating and characterising the various strains of *Flavobacterium psychrophilum* that exist on UK trout farms. In addition, they have gained a much better understanding of those factors that cause this bacterium to become virulent. This knowledge will hopefully form the basis of further vaccine work. Dr Sandra Adams of the University of Stirling will undoubtedly provide some insights when she presents a talk on RTFS at this year's Trout Farming Conference at Sparsholt.

Minimising the impact of aquaculture on the environment is a theme that is gathering momentum across all sectors of the industry. Fresh water cage culture of salmon and trout has become a matter of concern for the regulatory authorities in Scotland. Through LINK project TRT08, attempts were made to capture fish waste from cages and devise suitable methods for treating this effluent. Although the technique used to trap the fish waste was not effective, the project did provide some important insights into how such work should be conducted in the future. This project was driven very much from a practical perspective. Cage nets were modified and field experiments progressed largely on the basis of received wisdom. In retrospect, however, it became clear that, in order to trap the fish waste it is necessary to understand the hydrodynamics within the cage and their immediate vicinity. The expectation was that most fish waste would exit through the base of the cage, but modifications designed to trap waste falling in this trajectory caught only a fraction of the total effluent load. Eventually, current meter measurements suggested that much of the waste was probably leaving the cages within a couple of meters of the surface. An understanding of fish behaviour within the cage together with models of cage hydrodynamics, wind and current driven dispersion patterns, could allow new waste trapping designs to be modelled before incurring the expense of field trials.

Although fish disease has been the main focus of much trout related R&D, there have also been significant practical advances in other areas such as welfare. The Farm Animal Welfare Report on Farmed Fish was published in 1996, shortly after the LINK Aquaculture programme began. In response to this report, a number of lines of welfare research were initiated to address some of the reports recommendations and to provide a scientific basis for proposed regulation. A humane method of trout slaughter had long been mooted and a team from Silsoe Research Institute and the University of Bristol were eventually charged with developing a commercially viable slaughter system. With the appropriate electrical stunning parameters defined, a prototype machine affectionately known as 'Jeff's Fish Killer' after Dr Jeff Lines – its designer, was produced and has been successfully demonstrated at a number of farm sites around the UK. Although some farmers clearly desire a machine of lower cost and higher throughput, the principle has been proven to the satisfaction of both the Humane Slaughter Association and multiple retail customers. Alternative designs of machine will undoubtedly emerge, but what is of fundamental importance is that for the first time, the industry now has a scientifically defined, welfare justified set of criteria around which to develop slaughter systems.

Only two trout LINK projects are still underway, both are ultimately involved with improving fish quality. Flesh taint has long been a problem for some farms. The causes of taint have now been identified through project TRT13 (see below) and methods to both manage and eliminate taint are being developed, using the latest technology.

Looking to the future, fish genetics holds the key to a host of improvements through selective breeding. Using the natural variation that exists within the fish population project TRT12 (see below) is identifying a range of heritable traits that can be magnified to produce fish with desirable attributes. Quantitative genetics techniques are used to ensure that the selective genetic gain of a given attribute is maximised without increasing the problems that can result from inbreeding.

What next?

For the past six years, the LINK Aquaculture programme has been the principal mechanism for industry to seek targeted R&D through an integrated system. Industry, in collaboration with members of the scientific community have been encouraged to discuss and articulate their R&D requirements through their respective trade associations: LINK has been instrumental in helping formalising this process. Representatives of the trade associations have annually submitted their prioritised R&D portfolios to the Committee for Aquaculture Research and Development (CARD). Appropriate project areas have been taken forward through a process of open competition by the LINK Programme. Under LINK, the funds and resources of the principal sponsors were effectively pooled, providing a flexible and substantial resource upon which to draw.

However, in the absence of dedicated and co-ordinated funding strategy for aquaculture R&D, the prospects for the future funding look somewhat bleak. The research infrastructure that has been established over a number of years will become increasingly difficult to maintain and the lead that the UK currently has in many fields will inevitably be lost.

Post LINK, the funds available for aquaculture R&D in the UK have, in real terms, diminished significantly and are becoming increasingly fragmented. The scale of many funding allocations is insufficient to support projects of more than a few months duration. Funding bodies are tending to act in isolation, each operating its own policies and procedures. Opportunities to combine resources and maximise the leverage on other funding are being missed.

Government departments continue to sponsor valuable policy driven R&D at their agency laboratories. But much R&D expertise relevant to the development of aquaculture is based in universities and research institutes. The UK research councils tend to support R&D of a more fundamental nature and this work is, unashamedly, driven by scientific excellence and novelty, rather than the pragmatic requirement to find solutions to applied problems. Although funds are available through the EU Sixth framework programme, it is likely that the recent call for 'expressions of interest' will result in a few monumentally large projects, rather than specific emphasis on solving strategic R&D priorities for the UK industry.

The aquaculture industry is the fastest expanding food sector world-wide. For this growth to continue sustainably, it is of paramount importance to ensure that the R&D infrastructure on which the industry depends is properly resourced. As the various sectors of the aquaculture industry 'mature' their R&D requirements change and the rationale for the public support of this work must be carefully assessed. In an economically mature industry the responsibility for supporting R&D lies increasingly with the industry. Public support for aquaculture research is, however, generally justified on the basis of "market failure". The small companies that populate most of the industry are unable to fund research, whilst the few larger players face pressures to find solutions to immediate commercial concerns. With the 'risk/reward' equation stacked heavily in favour of risk for most aquaculture disease related research, there are few pharmaceutical companies prepared to commit significant resources to the development of new treatments.

Key to the success of the LINK programme has been the emphasis on collaboration between industry and the research community. Collaboration has been regarded both as a means by which appropriate expertise could be applied to relevant issues and problems, and as the means by which it could be ensured that the outputs and benefits of the research supported were widely disseminated and shared. An important facet of the Programme has been its support for research areas such as animal welfare and environmental protection, where the pursuit of commercial interests make it difficult to attract private funding (PACEC, 2000).

There is a need to increase investment in R&D, if UK aquaculture is to prosper in a global trading environment of disparate and variably applied regulation. It is vital that both Government and the industry adopt a strategic view of R&D and the need for a consistent investment policy to support it. Access to expertise and resources will be required if the industry is to remain competitive and sustainable whilst meeting the challenges of species diversification, disease control, minimisation of environmental impact and animal welfare considerations.

What is required, is the development of an infrastructure to facilitate the delivery of the available resources to a well founded, strategic portfolio of aquaculture R&D. For this to happen, key Government Sponsors, together with the Enterprise Networks and Local Authorities and industry, need to seek mechanisms to pool resources. It is important to bear in mind that even a modest R&D project can cost £150,000. For projects involving molecular science this figure can easily double. Only by forging meaningful partnerships where multiple sponsorship of projects can be dealt with in a streamlined and timely fashion can we hope to maintain the scientific momentum that underpins sustainable aquaculture development.

PACEC, 2000. Evaluation of the Aquaculture LINK Programme. Report for MAFF prepared by Public and Corporate Economic Consultants (PACEC). 61pp.

Project progress summaries:

Selective improvement of rainbow trout: mass selection and markers – TRT12

Project Leader: Professor Brendan McAndrew
Institute of Aquaculture
University of Stirling
Sponsor: NERC
Research Partner: University of Stirling
Industrial Partner: British Trout Association

The projects stated objectives are to identify breeding goals and produce a selection index for the UK rainbow trout industry. A number of visits to different farms, hatcheries, and processing facilities over the past few months has helped all involved to develop an in-depth understanding of the requirements of the different sectors. This has resulted in the plan to undertake two different breeding programmes during the coming spawning season. The first will be undertaken using the three different strains and broodstock ongrowing facilities at Glen Wyllin trout hatchery in the Isle of Man. This will involve setting up a number of pure and inter-strain crosses from PIT tagged and fingerprinted broodstock. The eggs from each family will be kept separate until shocking when equal numbers from each family will be combined in a commercial size population and put through a normal production cycle. Samples can be removed and assessed at critical points during the production cycle. Each individual will be measured for a range of traits and its family assignment determined using the genetic fingerprinting technique that has been optimised for this population. Using this approach we will have individual family data for a range of performance traits throughout the production cycle. This will identify the best families for each trait and parents generating them and the genetic correlation between the traits. The second breeding experiment will be based on the Trafalgar trout farm in Hampshire and will aim to identify whether there is any natural resistance to PKD, one of the major trout pathogens in the UK. A commercial size population will be constructed in the same way as in the IoM and the fish exposed to a natural challenge to the disease. Mortalities will be collected over the outbreak and genetically fingerprinted to identify their family using a fingerprint optimised for these strains. This will give a time series of mortality within families and will identify whether there is any innate resistance to this parasite in the Trafalgar strains. A preliminary trial to look at levels of infection and mortality levels and the subsequent effect of infection on performance is presently under way.

John Taggart and Jóse Ureta have already identified and analysed 12 highly variable DNA microsatellite loci (genetic fingerprinting) in seven widely used UK rainbow trout strains (see Table 1). They have developed a protocol that will enable a number of these loci to be assessed simultaneously enabling individual fish to be assigned to a single family in large commercial populations. This will require no more than a tiny sample of fin tissue and uses the Polymerase Chain Reaction technology to amplify the amount of the required DNA for subsequent analysis. The samples from individual fish are analysed on a semi-automatic gene sequencer system that turns the genotype data into a format suitable for subsequent parentage analysis by computer. This system allows relatively large numbers of fish to be analysed in a short period of time. The availability of these fingerprinting protocols means that we can design novel breeding programmes to look at a range of traits under commercial conditions on individual fish farms. This approach will maximise genetic gains while minimising any problems of inbreeding in the selected lines.

Table 1 shows the populations analysed, sample sizes, number of loci analysed, unbiased and observed heterozygosity and mean number of alleles per locus in seven UK commercial rainbow trout strains.

This data shows that there are still a large number of different alleles present in these strains. Therefore the chances of any individual having the same two alleles at each locus is very remote hence each individual will have a unique genetic fingerprint. Two different multilocus fingerprinting protocols have been developed for the different test farms.

For further information on this project you can contact Prof Brendan McAndrew at bjm1@stirling.ac.uk
Or write to him at the Institute of Aquaculture, University of Stirling, Stirling FK9 4LA.

Off-flavour problems in farmed trout: Identification of causative organisms and development of management strategies – TRT13

Project Leader: Dr Linda Lawton
The Robert Gordon University
Aberdeen
Sponsor: DEFRA
Research Partner: The Robert Gordon University
University of Stirling
Industrial Partner: British Trout Association

The cause of earthy/musty taints on UK rainbow trout farms is currently being studied in a joint project between The Robert Gordon University in Aberdeen and The Institute of Aquaculture at University of Stirling with The British Trout Association as our industrial partner. The taint compounds are known to be produced by a number of microorganisms and we have found cyanobacteria (also called blue-green algae) growing in thick mats in some farms. This is a problem that occurs mainly in the warm summer months when conditions are ideal for the growth of these microorganisms. Through the project we have established methods to detect the taint compounds known as geosmin and 2-methylisoborneol in the laboratory using analytical instruments (gas chromatography - mass spectrometry). These methods have enabled us to reveal the presence of substantial quantities of geosmin in cyanobacterial mats found in a trout farm. In farms the cyanobacteria release the taint compounds which then rapidly accumulate in flesh of fish. Removal of taint from the trout flesh appears to take much longer than the initial accumulation. Our current studies are investigating how long it takes for tainted trout to become clear of geosmin to enable trout to be purged of taint prior to harvest. This improved understanding will help trout

Table 1.

Population	Sample size	Loci typed	Unbiased Hz	Unbiased Hz SD	Obs Hz	No Alleles	No Alleles SD
I	50	12	0.7959	0.0276	0.5766	11.50	3.32
II	50	12	0.7806	0.0295	0.5675	10.25	2.53
III	49	12	0.7819	0.0234	0.5537	10.58	2.91
IV	70	12	0.6683	0.0411	0.5537	7.00	2.73
V	55	12	0.7279	0.0375	0.6038	10.50	4.76
IV	27	12	0.7467	0.0287	0.6827	6.75	1.76
IIV	49	12	0.5741	0.0376	0.4963	6.42	1.73

farmers develop management strategies to effectively deal with taint episodes.
Using laboratory techniques we have determined that geosmin is consistently the main taint-causing compound found in UK trout farms. In our laboratory studies we have also shown a direct correlation between palatability in taste panel tests and the concentration of geosmin present. Our current estimation for taint threshold in trout is 1.5 µg/kg of geosmin.

For further information on this project you can contact Dr Linda Lawton at l.lawton@rgu.ac.uk
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UPDATE ON RESEARCH INTO PROLIFERATIVE KIDNEY DISEASE (PKD) – A CO-ORDINATED APPROACH

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In a previous Trout News article (Number 30, July 2000, pages 25-27) Dr Caron Montgomery provided a summary of the main findings and recommendations from a meeting held at CEFAS Weymouth in October 1999. The aim of the meeting was to review the current state of knowledge and to identify research priorities. At that time, the role of bryozoans in the lifecycle of *Tetracapsula bryosalmonae* and their involvement in the transmission of the parasite to fish had only just been discovered, this offering new and exciting possibilities for the development of improved control strategies for the disease. Following the recommendations from the meeting on research priorities, work was commissioned by DEFRA in the area of immunology of PKD. This complemented the existing programme of work on PKD, funded by DEFRA at CEFAS Weymouth, investigating the lifecycle and transmission requirements of *T. bryosalmonae* and other myxozoan parasites. NERC-funded work on the ecology and the effect of the parasite on the bryozoan hosts being undertaken at the University of Reading by Dr Beth Okamura also addresses research priorities identified at the meeting.

Two new projects targeting the immunology of the disease were started in October 2001. These are being undertaken at the Institute of Aquaculture, University of Stirling (IoA) (with financial support from the British Trout Association and extending their previous research in various aspects of PKD) and at the University of Aberdeen, led by Dr Sandra Adams and Professor Chris Secombes respectively.

The main objective of the work at Stirling is ‘To develop *in vitro* and *in vivo* culture methods for *T. bryosalmonae* and to elucidate the immune response of the fish host to the parasite’. The propagation, culture and purification of the parasite will enable controlled experiments to be conducted on the immune response of fish to the parasite. Identification and characterisation of the antigens inducing a response in the host will provide a better understanding of host-pathogen interactions during infection and recovery and will lead to the development of effective control strategies for *T. bryosalmonae.*

Studies at Aberdeen are aimed at using cutting-edge molecular techniques to gain an in-depth understanding of the nature of the fishes immune response during PKD infection leading to pathology or immunity. Specifically, to examine the expression of a wide range of immune and inflammatory genes, already available at the Aberdeen laboratory, from the kidneys of naive and previously exposed rainbow trout collected during the course of a PKD infection. Following on from these initial studies, recent advances in molecular biology will be employed to identify novel immune genes involved in the pathology associated with PKD infection and with immunity to re-infection observed in recovering fish. In using the same techniques to identify novel genes associated with the infection of the secondary bryozoan host, research at Aberdeen can potentially lead to the identification of novel parasite genes as well as those involved in the host response.

Overall, a greater understanding of host responses to infection may help to target treatments to reduce pathology without interfering with the induction of protective immunity, with the additional benefit of using novel parasite genes as potential vaccine antigens.

These projects are co-ordinated as the ‘PKD programme’ with a project board chaired by SWF in order to:

- Enhance collaboration and communication between research groups.
- Co-ordinate activities.
- Provide additional project monitoring and regular updates to DEFRA, the BTA and other interested parties.
- To establish training as required.
- To facilitate dissemination of research findings to a wider audience.

The first progress meeting was held at the IoA on the 7 December 2001. Since the newly funded work had barely begun the emphasis of the meeting was to establish a clear basis from which the various projects would integrate and support each other. This was successful and since then there has been regular communication and visits between laboratories for field sample collection, provision of archive material and of course discussions on the research itself.

An important part of both of these studies is the development of a large-scale bryozoan culture system. This being required to study infections with *T. bryosalmonae* in the bryozoan host (work currently underway at Reading) and also to provide sufficient quantities of parasite material for the studies outlined above – the 'parasite factory'.

Consequently, to date the main efforts at Stirling have been to develop large-scale cultures of infected bryozoans to provide material for future study. For this work a defined diet has been developed for the optimal growth and feeding of different bryozoa species. Through collaboration with the group at Reading a culture system has now been developed that allows bryozoans to be grown in bulk in laboratory controlled conditions. The other aspect of the work has been on growing the kidney stage of the parasite *in vitro* (in a test tube). This work has focused on developing novel culture media and conditions for the parasite, and in particular the use of renal cell lines to support parasite growth. One of the findings of this research is that distinct biochemical differences appear to be present between the blood and the kidney stages of the parasite.

At Aberdeen good progress has been made with regards to the examination of known immune/inflammatory genes during a PKD outbreak. From the 2001 season, out of five genes studied so far four are up-regulated, although variable expression is seen in kidney samples from the naive fish group exhibiting pathology (mid-way through season) compared with naive uninfected controls.

Although the parasite was not detected in bryozoans in 2001, the disease in fish still occurred in fish farms and experimental trials using bryozoans from sites known to be affected by PKD transmitted the infection to naïve fish. The aim of this work at CEFAS was to establish how the parasite enters the fish and how it spreads within the host before the well known clinical signs occur and has since been published. This year however, the parasite was again detected (by CEFAS) (Figures 1, 2, 3), and intensive activity resulted in the collection of material for all parties in the PKD programme. This allowed the Weymouth group to investigate the behavior of the parasite after release from the bryozoan host and provided material to set up experiments examining transmission to grayling and salmon as well as to cultured bryozoans (with Beth Okamura). Parasite material was retained for the molecular studies at Aberdeen, Stirling and Reading. The results of all of these studies will take some time to come through but progress will be reported regularly in Trout News.

Figure 1. A small colony of Fredericella sultana, one of the bryozoans implicated in transmission of Tetracapsula bryosalmonae, is shown here with the lophophores, or feeding appendage extended. L= Lophophore

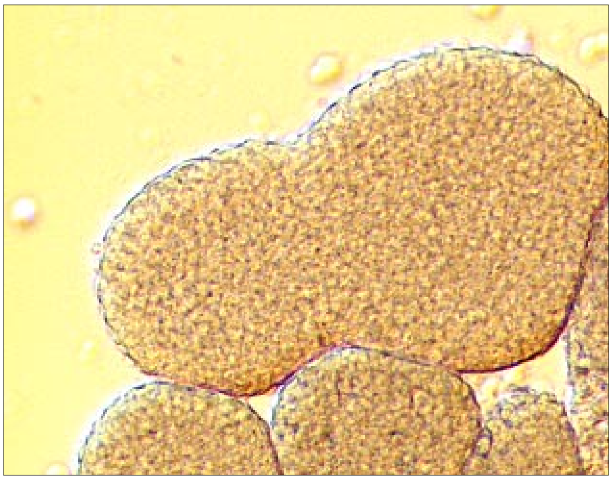

Figure 2. Isolated Tetracapsula bryosalmonae sac released from a bryozoan, which appears to be dividing. The sac contains several hundred spores, each of which potentially can infect salmonids leading to PKD

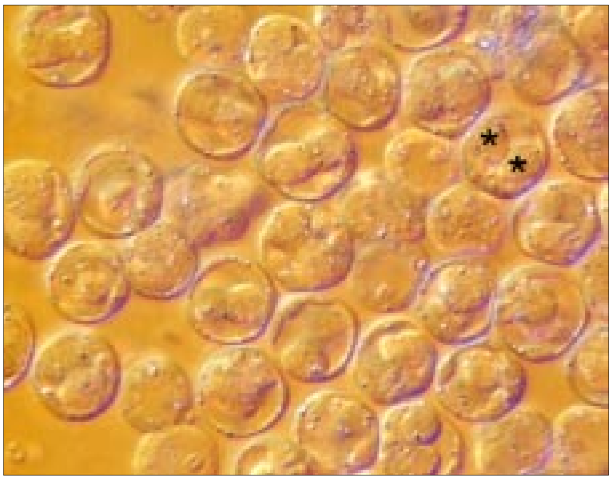

Figure 3. Tetracapsula bryosalmonae spores released from a sac. Each spore contains two infective sporoplasm cells (*)

RESEARCH NEWS

1. Awareness and pain in fish

In recent years, commercial and sport fisheries have been challenged increasingly on grounds of humaneness. A principal underlying the assumption of the scientific and non-scientific challenges is that fishes are capable of suffering from pain in a manner similar to that experienced by humans. This review examines the neurobehavioral nature of fishes and addresses the question of whether fishes are capable of experiencing pain and suffering. The detrimental effects of anthropomorphic thinking and the importance of an evolutionary perspective for understanding the neurobehavioral differences between fishes and humans are discussed. The differences in central nervous system structure that underlie basic neurobehavioral differences between fishes and humans are described. The literature on the neural basis of consciousness and of pain is reviewed, showing that: (a) behavioural responses to noxious stimuli are separate from the psychological experience of pain, (b) awareness of pain in humans depends on functions of specific regions of cerebral cortex, and (c) fishes lack these essential brain regions or any functional equivalent, making it untenable that they can experience pain. Because the experience of fear, similar to pain, depends on cerebral cortical structures that are absent from fish brains, it is concluded that awareness of fear is impossible for fishes. Although it is implausible that fishes can experience pain or emotions, they display robust, non-conscious, neuroendrocrine, and physiological stress responses to noxious stimuli. Thus, avoidance of potentially injurious stress responses is an important issue in considerations about the welfare of fishes.

Reference

SPTF-!K/E/!(Department of Zoology and Physiology, University of Wyoming, Laramie, WY 82071. e-mail: trout@uwyo.edu), 2002. The neurobehavioral nature of fishes and the question of awareness and pain. Reviews in Fisheries Science, 10(1): 1-38.

2. Effect of dietary phosphorus and vitamin D on phosphorus excretion

Because the concentration of phosphate is low in natural waters fish must obtain phosphorus (P) from their food and for rainbow trout the requirement is 0.4 – 0.6%. This is derived from P naturally present in fish meal and from supplementation of the diet. However, the efficiency of utilisation is only 60% at a 0.6% dietary P level and may be lower where supplementary P levels exceed this requirement for optiamal growth. A consequence of low utilisation is a significant fraction of dietary P is excreted leading to eutrophication of natural fresh waters. This study looked at the effect of decreasing dietary P levels and increasing dietary vitamin D (which enhances P assimilation in mammals) levels in attempts to enhance P assimilation and reduce excretion levels. Soluble effluent P reached a peak right after feeding and returned to baseline levels in between feeding times. The peak and average concentrations of soluble P in the effluent were mainly influenced by dietary P. Average P in feacal dry matter also decreased with dietary P. Neither dietary P nor vitamin D under the conditions of the experiment had significant effects on whole body P content but P deposition (as a percentage of P intake) decreased with increased dietary P. The dietary combination of low P and high vitamin D decreased soluble and feacal P levels in the effluent indicating a strategy whereby effluent P concentrations can be reduced by regulation of P metabolism.

Reference

DPMPTP-!S/N/-!CBTBOUFT-!T/Q-!LJOH-!L/-!IFOESJY-!N/B/-!GMFUDIFS-!K/X/-!XFJT-!Q/!BOE!GFSSBSJT-!S/Q/!(Department of Pharmacology and Physiology, UMDNJ-New Jersey Medical School, MSB-H621, 185 S. Orange Ave., Newark. NJ 07103-2714 USA. E-mail: ferraris@umdnj.edu), 2001. Effect of dietary phosphorus and vitamin D_3 on phosphorus levels in effluent from the experimental culture of rainbow trout (*Oncorhynchus mykiss*). Aquaculture, 202(1&2): 145–161.

3. Effect of feed frequency on growth

Growth rate and variation in size is a useful tool in practical fish farming for measuring the welfare of fish stocks. Growth variations result in the formation of dominance hierarchies and territorial behaviour in small fish groups and aggressive interactions in full scale rearing conditions. The mode of feeding may affect the amplitude of the size variation by making feed more accessible for less competitive individuals and more difficult for dominant ones. The aim of this study was to compare the effect of feeding the daily food ration using a few concentrated meals or small frequent meals during the day for 1+ Arctic charr and rainbow trout under full-scale hatchery conditions. Triplicate hatchery groups for each treatment were fed at a ration level of 1% per day either with few meals (8 times per day divided into morning and evening) or with frequent meals (32 meals equally distributed during the day). An opposite effect of meal frequency on growth was found in the two species. Low feeding intensity (8 meals per day) had a significantly positive effect on growth in rainbow trout but a significantly negative effect on growth in Arctic charr when compared to feeding the fish frequent meals. The opposite response to meal frequency is likely to be an effect of the differences in activity during feeding. Rainbow trout feed much more aggressively than charr which can result in feeding being a more stressful event. In this experiment, the specific growth rate was lower and the feed conversion ratio higher for Arctic charr compared to rainbow trout. The reasons behind these differences are not fully established but could be due to the effect of selection where faster growing individuals that feed aggressively are favoured. Since rainbow trout have been farmed and selectively bred over a longer period of time, these traints are more apparent than those seen in charr.

Reference

MOO¤S-!K/!BOE !CS¡ OO¡ T-!F/!)Department of Aquaculture, SLU, S-901 83 Umeå, Sweden. E-mail: eva.brannas@vabr.slu.se). 2001. Growth in Arctic charr and rainbow trout fed temporally concentrated or spaced daily meals. Aquaculture International, 9(1):35–44.

4. Performance of triploid Atlantic salmon

Research on sterile salmonids using triploidy has developed as a response to the problem of early maturation and consequent losses in production and also later in alleviating the concerns over interactions between escaped farmed salmon and wild stocks. This paper compares the performance of all-female diploid (AF2N) and triploid (AF3N) Atlantic salmon in fresh water, under commercial production conditions in 1995 and 1996 year classes. The performance of the 1996 year class was also assessed for14 months in a commercial sea farm. Freshwater mortality was higher in the triploid groups. The majority of losses occurred in the early stages of egg development and during the first feeding period, when the incidence of non-feeding fry was consistently higher. In growth studies, although diploid fry were significantly heavier during first feeding there were no significant differences in weight between groups some 8 months after fertilization or in pre-smolt growth periods from February to April in 1996 and 1997. Smolting rates were high (range 93.5 – 95.3%) and the incidence of deformities was low (< 1%) in both groups. Marine survival was lower in the triploid groups, largely as a consequence of higher losses sustained during a period of chronic stress, when triploid losses were 9% higher. Growth patterns were similar for the first 11 months in sea water. Although graded triploid salmon were heavier in January 1998 (AF3N 1.62 ± 0.033 kg, AF2N 1.46 ± 0.36 kg, $P < 0.05$), when the fish were harvested in May 1998 diploid salmon were significantly heavier than triploid salmon although there was no significant difference in weights after evisceration (AF3N 2.4 kg ± 0.04 AF2N 2.49 kg ± 0.03). The increase in weight of the diploids between winter and harvest reflects the growth spurt that occurs in maturing fish in the spring. Overall yields of triploid salmon in salt water were lower as a result of inferior survival.

Reference

DPUUFS-!E/ (SMSD, Marine Institute, Newport, Co. Mayo, Ireland. E-mail: smoltunit@sra.iol.i.e), O'Donovan, V., ESVNN-!B/-!SPDIF-!O/-!MOH-!F/O/!BOE !XJMJOT-!O/Q/-! 2002. Comparison of freshwater and marine performances of all-female diploid and triploid Atlantic salmon (*Salmo salar* L). Aquaculture Research, 33(1): 43–53.

5. Influence of dietary carotenoids on bio-defense mechanisms

The use of prophylactic as well as therapeutic drugs has increased in response to the frequent occurrence of disease in aquaculture systems. This has raised concerns over the development of drug resistance in fish pathogens. Diet has been shown to influence resistance to infections through both innate and acquired immune mechanisms. Therefore immunoenhancement by dietary manipulation may complement or offer an alternative to the use of drugs. There is growing evidence that carotenoids are beneficial supplements for various aquaculture species affecting growth, broodstock performance and enhanced resistance to disease. In addition fish deficient in vitamins A, C and E show reduced haemolytic serum complement activity and plasma total immunoglobulin content in trout. The objective of this study was to explore the influence of different synthetic carotenoids either in the presence or absence of vitamins A, C and E on the non-specific immune response indices as well as growth and feed utilisation in rainbow trout. Six semi-purified casein-based diets were formulated to contain astaxanthin, canthaxanthin and β-carotene, at 100 mg kg, each of them with vitamins A, C and E either added or omitted. The two control diets contained no carotenoids and were either with or without the vitamins. Rainbow trout weighing about 140 g were fed the diets for 9 weeks. Specific growth rate, feed: gain ratio and nonspecific immune parameters were determined. Growth and feed conversion were similar among all the groups. Immune parameters like production of reactive oxygen species by head kidney leukocytes and plasma total immunoglobulin levels did not vary with the treatment. Serum complement activity in both β-carotene groups and the vitamin-containing astaxanthin group were significantly higher than both the control fish. Serum lysozyme activity in the vitamin-containing β-carotene and astaxanthin groups were significantly different from both control groups. Phagocytic activity was also high in the vitamin-containing β-carotene and astaxanthin groups compared with the controls. For phagocytic index, in addition to the foregoing groups, the vitamin-containing canthaxanthin group gave better results compared with the controls. The vitamin-containing astaxanthin and β-carotene groups also exhibited better nonspecific cytoxicity for the peripheral blood lymphocytes at all effector-to-target ratios. Thus among the carotenoids studied, β-carotene and astaxanthin elevated humoral factors such as serum complement and lysozyme activity, as well as cullular factors such as phagocytosis and nonspecific cytotoxicity. In the presence of the vitamins the carotenoids exerted a greater influence on the bio-defense mechanisms of rainbow trout.

Reference

Bnbs-!F/D/-!Ljspo-!W (Department of Aquatic Biosciences, Tokyo University of Fisheries, Konan 4, Minato, Tokyo, 108-8477, Japan), Tbupi -!T/!boe !Xbubobcf-!U/-! 2001. Influence of various dietary synthetic carotenoids on bio-defence mechanisms in rainbow trout, *Oncorhynchus mykiss* (Walbaum), 32 (Suppl. 1): 162–173.

6. The use of dehulled lupin in trout diets

Protein is the most expensive nutrient in aquaculture feeds and finding alternative cheaper sources has long been a challenge for nutritionists. Lupin has potential as a fish meal replacement for trout and its production in Australia is the highest of the grain legumes sown (1.421 milllion tonnes in 1998/99). The hull of lupin constitutes 25% of the seed and contains approximately 90% dietary fibre; its removal intensifies the protein and dilutes the carbohydrate content resulting in a higher inclusion of it in the diet. This paper determined the maximum dietary inclusion level of dehulled lupin as a replacement for fish meal in rainbow trout diets with respect to growth, physiological and immunological responses. Fish were fed diets with 0%, 20%, 30%, 40% and 50% of lupin, at a daily feeding rate of 2% body weight for 8 weeks at 15 ± 0.5ºC. Growth performance generally decreased with increasing lupin in the diet. However, there was no significant difference between 0%, 10%, 20%, 30% and 40% lupin fed groups. Feed conversion ratio generally increased at higher inclusion levels of lupin. The protein efficiency ratio, protein productive value, lipid efficiency ratio and lipid productive value were similar in all groups but the energy efficiency ratio was significantly lower in the 50% lupin fed group. Different treatments showed similar digestive enzyme activity, villus height, pyloric caeca and hepato somatic indexes. None of the nonspecific immune responses, with the exception of total plasma protein and neutrophils, was affected by different inclusion level of lupin. Results show that dehulled lupin can be included at up to 40% of a rainbow trout diet without a significant affect on growth performance or nutrient utilization. Rainbow trout utilise lupin protein as efficiently as fish meal protein but have a lower ability to utilize the energy content of lupin at higher inclusion levels.

Reference

Gbsi boh-!N / (School of Aquaculture, Tasmanian Aquaculture and Fisheries Institute, University of Tasmania, Locked Bag 1-370, Launceston, Tasmania, 7250, Australia. E-mail: mfarhang@utas.edu.au) boe !Dbsufs-!D/H/- 2001. Growth, physiological and immunological responses of rainbow trout (*Oncorhynchus mykiss*) to different dietary inclusion levels of dehulled lupin (*Lupinus angustifolius*). Aquaculture Research, 32 (Suppl. 1): 329 –340.

7. Production of all-female populations of fish for aquaculture

Females of many of the fish species used or proposed for aquaculture in Atlantic Canada have the potential to be more valuable than males. Depending upon the species in question, they have faster growth rates as juveniles, are older at sexual maturity, reach a larger ultimate size, and/or are a source of roe or caviar. In comparison to traditional terrestrial livestock species, it is relatively simple to produce all-female populations of fish through genetic (gynogenesis), endocrine (steroidal), and/or environmental (thermal) manipulations. Recent advances in molecular biology, such as microsatellite markers and sex-specific genetic markers, have facilitated the application of these technologies to aquaculture. This paper reviews the methods, and updates the status, of sex control research and development in local (Atlantic Canada) aquaculture species.

Reference

Cfogfz-!U/K/!(Professor and Director of Graduate Studies in Biology, University of New Brunswick, Fredericton, NB Canada E3B 6EI. E-mail:benfey@unb.ca), Nbsujo. Spcjdi bve-!E/K/-!I foesz-!D/J/-!Tbdpcjf-!D/-!Uwfeu-!I /! boe !Sfjui -!N /- 2000. Production of all-female populations of fish for aquaculture. Bulletin of the Aquaculture Association of Canada, 100(3): 13–15.

8. Biological control of the fish louse

The fish louse *Argulus foliaceus* is an ectoparasite of many species of freshwater fish in Britain and Ireland. In the last decade along with other species of Argulus it has emerged as a problem for sport fish in the UK. The louse deposit eggs as strings or clutches on hard substrata, usually within 1 m of the water surface and one approach at biological control, developed for fish farms in Eastern Europe, involves the use of wooden boards that serve as substrata for egg laying. This study investigated the effectiveness of novel egg-laying boards, made of opaque light-weight corrugated polypropylene, in disrupting the life cycle of *A. foliaceus* in a rainbow trout fishery (12.9 ha) that failed to recover fully from an epizootic 4 years earlier. The boards, which were anchored horizontally within the top 6mm of the water surface or floated vertically in the water column at any selected depth, were used continuously from early May to early November during 1999 and from early April to early November during 2000. The boards were replaced every 2 weeks, cleaned of organic matter, dried and the egg clutches counted. Approximately 228,000 egg clutches were harvested during an extensive 14 week period of egg laying which peaked in June 1999. In contrast, only 1566 clutches were harvested in 2000, when egg laying activity showed a bi-modal distribution, peaking in

May and again in July and August. Egg laying activity decreased 145-fold compared to 1999. *A. foliaceus* prevalence and mean intensity also decreased nine-fold and six-fold respectively. The ratio of female to male *A. foliaceus* on rainbow trout in consecutive years was 2.9:1 and 2.1:1. Estimates of the size of the female lice population based on egg-laying activity in 1999 exceeded that derived from measurements of prevalence and intensity of infection, whereas in 2000, this was more in balance. A minimum temperature of 10°C was identified for egg laying, which occurred continuously from May to October in a broadly synchronous manner. This produced almost two generations each year, with juveniles, adults and eggs undergoing anabiosis during winter. These results showed that egg-laying boards offer considerable promise as a practical method for biological control of this parasite in fisheries. They should be deployed throughout the breeding season when the water temperature is greater than 10°C and replaced at 2 week intervals or more regularly during the warmer summer months, to prevent egg clutches from hatching.

Reference

Hbvmu-!O/G/!(Food Science Division, Department of Agriculture and Rural Development, Newforge Lane, Belfast, BT9 5PX, Northern Ireland. E-mail:Norman.Gault@dardni.gov.uk), Ljmqbusjdl-!E/K/!boe!Tufxbsu-!N/U/- 2002. Biological control of the fish louse in a rainbow trout fishery. Journal of Fish Biology, 60(1): 226–237.

9. Growth performance of fast and slow growing strains of rainbow trout

Differences in growth performance between rainbow trout strains have partly been attributed to feed intake. While distinct feeding behaviour may be based on the capacity to ingest food, differences in appetite or feeding rhythm may also be involved. An appraisal of these factors requires the fish's response to food be assessed in quantitative terms. Self-feeders are useful for this as the fish themselves accurately control the feeding level by activating a trigger whilst at the same time recording each feeding event providing information on feeding rhythms. The aim of this work was to evaluate whether differences in growth performance due to genetic origin of the fish could be attributed to differences in appetite or feeding rhythms. Rainbow trout (8.5 – 9.5 g) of two strains (C and M) differing in growth potential were compared with respect to feeding motivation and feeding rhythms over a 65-day experimental period using self-feeding or automatic feeding. Growth rate, feed gain ratio, feed intake and pattern of feeding activity of fish fed with self-feeders, were recorded, as was body composition of both strains. The final weight of fish of the fast-growing strain C, fed using self-feeders, was significantly higher (82.6 g) than that observed for fish of the slow-growing strain M (69.3 g). When the automatic feeders were used, no significant differences were found between the strains in terms of body weight gain (65 g). Results observed for feed gain ratio were also similar between the two strains. Although the voluntary feed intake (VFI) did not vary significantly with the genetic origin of the fish, strain C displayed a consistently higher VFI compared to strain M. The retention efficiency of nutrients and energy were similar between strains but significantly different between feeding systems. With regard to body composition, when fish were fed by means of self-feeders, no significant differences were found between the two strains. However, when fed automatically, dry matter and lipid content were highest in the strain M fish. The energy and protein content of the whole fish were not significantly influenced either by the feeding system or by the strain of the fish used. It was concluded that the increased growth performance of the fast-growing strain was due to the expression of a bigger appetite that gave rise to a higher capacity of the fish to ingest food. The feed gain ratio and retention efficiency of nutrients and energy were similar between strains.

Reference

Wbmfouf-!M/N/Q/ (Departmento de Engenharia Biológica e Ambiental, Universidade de Trás-os-Montes e Alto Douro, Apartado 202 5001, Vila Real, codex, Portugal. E-mail: lvalente@utad.pt), Gbvdpoofbv-!C/-!Hpnft-!F/G/T/!boe! Cpvkbse-!U/- 2001. Feed intake and growth of fast and slow growing strains of rainbow trout (*Oncorhynchus mykiss*) fed by automatic feeders or by self –feeders. Aquaculture, 195(1 and 2): 212–131.

10. Susceptability of char, brown and rainbow trout to ISA

Infectious salmon anaemia (ISA) is a serious disease of Atlantic salmon and an understanding of potential reservoirs of the causative agent is of fundamental importance to its management and control. Replication of Norwegian ISA virus has been experimentally demonstrated in brown trout, sea trout and rainbow trout. Arctic char is now increasingly farmed in Scotland but little is known concerning the potential role of this species in the epizootiology of ISAV. Consequently the aim of this study was to investigate the replication of Scottish ISAV in Arctic char, rainbow and brown trout. Following intra-peritoneal injection of ISAV in pathogen-free fish no mortalities were recorded although transient drops in haematocrit were recorded. Sub-samples of all species were screened for the presence of ISAV using RT-PCR and virus culture. While virus was unculturable from all samples at 40 days post-infection, virus was detectable using RT-PCR in all species. Clearance of virus following experimental infection did however progress at a greater rate in Arctic char then in rainbow trout and brown trout. The potential for this species to act as a long-term carrier of ISAV, and thus exert a role in the epizootiology of ISAV in Scotland may be less than in other salmonid species. The increasing commercial production of Arctic char render these findings significant to the future management of ISAV in Scotland.

Reference

TOPX-!N/!(FRS Marine Laboratory, P.O. Box 101 Victoria Road, Aberdeen, AB11 9DB, Scotland, UK. E-mail: snowm@marlab.ac.uk), SBZOBSE-!S/T/!BOE!CSVOP-!E/X/- 2001. Comparative susceptibility of Arctic char (*Salvelinus alpinus*), rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*) to the Scottish isolate of infectious salmon anaemia virus. Aquaculture, 196(1 & 2):47–54.

11. Protection from furunculosis using probiotics

Aeromonas salmonicida is the causative agent for furunculosis, a major fish disease where mortality may be as high as 80 – 90%. Although effective commercial vaccines are available vaccination cannot prevent development of disease in young and small fish, and consequently major economic losses may occur at the hatchery stage. Antibiotics can be effective in young fish but have several drawbacks. Probiotics provide a potential alternative method of protection. The present study aimed to investigate if a probiotic strain, intended for human use of *Lactobacillus rhamnosus*, ATCC 53103, would be able to protect rainbow trout from furunculosis. A probiotic for human use was specifically chosen since it has been shown to be safe which is of major importance since fish are usually farmed for human consumption. The bacterium was administered in the feed at two different doses (10^9 and 10^{12} CFU/g) for 51 days. Sixteen days after the start of the *Lactobacillus* feeding, the fish were challenged with *A. salmonicida*. During the challenge trial the mortality was monitored. *L. rhamnosus* reduced the fish mortality significantly, from 52.6% in the control to 18.9% and 46.3% in the 10^9 CFU/g feed and the 10^{12} CFU/g feed groups, respectively. The results suggest that this strain, although intended for human use, may provide affective protection from furunculosis in rainbow trout without risks for subsequent human consumption.

Reference

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12. Effect of density on routine metabolic expenditure

In intensive rearing systems, increasing fish stocking density is one way to optimize productivity. However, high rearing density is also a potential source of stress that may constrain fish growing capacity. This detrimental effect on growth is partly mediated through behavioural alterations (increased social interactions, aggression or chasing), which generate supplementary metabolic expenditure and most likely alter feeding behaviour. In this study, the effects of rearing density was studied on the routine metabolic rate (RMR) of rainbow trout. Concurrently, and in order to determine the bioenergetic significance of the density-dependent changes in RMR, the animal's metabolic scope was estimated. Respirometry experiments were conducted at three densities: 25, 65 and 100 kg m^3 using 11°C-acclimated starved individuals (261 ± 5g). Under the experimental conditions prevailing, no significant variations of RMR were detected between 25, 65 and 100 kg m^3. Aerobic metabolic scope was estimated at 285 mg oxygen kg h. When analysed with regard to metabolic capacities, RMR amounted to less than 15% of fish metabolic scope. Furthermore, at all densities the RMR diel cycle was preserved and inter-group variability in RMR was highly significant, reinforcing the idea that density was not a determinant factor of the rainbow trout RMR under the prevailing experimental conditions. It was concluded that in the range tested, density did not burden the metabolic resources of the experimental fish. Although the experimental conditions may not have been exactly representative of general aquaculture conditions, the study provided insight on the energy expenditure in rainbow trout held in captive facilities.

Reference

MFGSBO£PJT-!D/!(Centre de Recherche en Ecologie Marine et Aquaculture (CNRS-Ifremer), BP 5, L'Houmeau 17137, France. E-mail: clefranc@ifremer.fr), DMBJSFBVY-!H/-! NFSDJFS-!D/!BOE!BVCJO-!K/- 2001. Effect of density on the routine metabolic expenditure of farmed rainbow trout (*Oncorhynchus mykiss*). Aquaculture, 195 (3 & 4): 269–277.

13. Quality of farmed salmonids

Salmonid aquaculture has focused for many years on enhancing the quantity of fish produced. However, optimisation of the quality of salmonids may lead to improved consumer acceptance and higher prices for the farmed product. This review evaluates how the quality of salmonids is affected by parameters such as feed type, level of dietary intake (ration) and growth. Feed composition has a major influence on the proximate composition of salmonids. In particular, whole body lipid as well as the lipid content in the edible fillet is directly related to dietary fat content, while the fatty acid composition of the fish flesh is also strongly influenced by the dietary fatty acid profile. White fish body composition appears to be largely influenced by feed composition, an increase in other parameters such as feed ration and fish size also results in enhanced adipose deposition and decreased water content in the fish body. The protein content, however, remains more or less stable. An increase in fish body lipid content is not necessarily a negative factor, depending upon the processing procedure that follows. However, an increase in body fat content is generally accompanied by a reduction in slaughter yield, owing to an increase in the weight of viscera in relation to body weight. Although salmonid flesh quality with respect to levels of proximate constituents and yield appears to be under the strong influence of feed composition and feed amount, the sensory characteristics, such as odour, flavour, texture, etc., are only governed by these factors to a small degree. Tactics for the rearing of salmonids for specific purposes should therefore take into consideration the fact that the level of proximate constituents in the whole body as well as the fillet are readily manipulated by feed composition and feeding strategies. Whereas the sensory parameters are less affected by these variables.

Reference

Sbtnvttfo-!S/T/!(Ågade 22,1.th., 9000 Åalborg, Denmark. E-mail: gitric@get2net.dk), 2001. Quality of farmed salmonids with emphasis on proximate composition, yield and sensory characteristics. Aquaculture Research, 32(10): 767–786.

14. Use of gonadotropin hormone for the control of reproduction

The most commonly observed reproductive dysfunctions in cultured fish are the unpredictability of final oocyte maturation (FOM) in females, and the diminished volume and quality of sperm in males. Gonadotropin-releasing hormone agonists (GnRHa) have been used extensively in order to stimulate the release of pituitary luteinizing hormone (LH) required to induce FOM, ovulation and spermiation. Because multiple hormonal treatments are often necessary for a successful response, fish must be monitored and handled extensively, which is labour intensive, stressful to the fish and can often result in broodstock mortalities. To ameliorate this problem, sustained -release delivery systems for GnRHa have been developed during the last two decades and have been increasingly applied in controlling reproduction of a variety of cultured fish. Solid implants of cholesterol or poly[ethylene-vinyl acetate], and biodegradable microspheres of poly[lactide-glycolide] or poly[fatty acid dimer-sebasic acid] release GnRHa for a period of time (from a few days to many weeks). GnRHa-delivery systems do not cause desensitisation of the pituitary gonadotrophs in fish, and by stimulating a sustained elevation of plasma LH they induce the natural progression of plasma steroid increases associated with FOM and spermiation. This method has been used with very encouraging results in females of more than 40 cultured species and has been effective in inducing FOM, ovulation or spawning in fish with synchronous, group-synchronous and asynchronous ovarian development. In males, GnRHa-delivery systems have been tested in more than 20 species, producing significant increases in milt production for up to 5 weeks. Future research should focus on the optimisation of this technology in terms of (a) using the most potent GnRHa, (b) identifying the most appropriate GnRHa release kinetics according to the reproductive biology of different species, and (c) determining minimum effective doses. Developments in these areas will greatly enhance the effectiveness and efficiency of GnRHa-delivery systems, while at the same time reducing their cost thus making them more affordable to the aquaculture industry.

Reference

Nzmpobt-D/D/!(Institute of Marine Biology of Crete, P.O. Box 2214, Heraklion, Crete 71003, Greece. E-mail: mylonas@imbc.gr) boe![pi bs-Z/- 2001. Use of GnRHa-delivery systems for the control of reproduction in fish. Reviews in Fish Biology and Fisheries, 10(4): 463–491.

15. Influence of raceway design and substrate on fin erosion

Fin erosion is common among fish raised in modern large-scale culture operations. Fish with eroded fins may be aesthetically displeasing to anglers, may have impaired survival and prone to bacterial and fungal infections. Abrasion from rough concrete has been cited as one contributory cause and the objective of this study was to isolate factors that may improve fin condition in rainbow trout. The factors looked at were (a) evaluating several raceways and gravel substrates that would withstand regular cleaning and allow elimination of waste. (b) examine whether the three-dimensional structure or simply the appearance of gravel in the raceway improved fin condition. (c) examine whether raceway surface quality (smoothness) contributed to better fin conditions and (d) evaluate whether a cross-flow raceway design, with or without gravel would distribute fish such that aggression and dominance (resulting in fin nipping) would be reduced and thereby decrease fin erosion. In the first trial, fish were reared in either conventional concrete raceways or raceways fitted with a false floor overlaid with cobble through which water and waste materials flowed. Growth, feed conversion, and mortalities were not influenced by treatment type, but fish reared in false-floor raceways exhibited an improvement in fin lengths. For trial (b), fish were raised in control raceways or raceways that contained two-dimensional, painted gravel patterns (2D) as a substrate or actual gravel affixed to the raceway bottom (3D) to provide a three-dimensional appearance. Growth, feed conversions, and mortalities were not influenced by treatment type, but fish in the 3D treatment had significantly better dorsal fins compared with the control and 2D groups. Anal fins, pelvic fins, and right-pectoral fins were significantly better for control and 3D fish compared with 2D fish. For trial (c) fish were reared in either control raceways or raceways with walls and bottoms that had been smoothed by the application of a resin. Fish performance was not affected by raceway coating. However, fish reared in the coated raceways had significantly more fin erosion than control fish over the course of the study, although by the end of the study these effects appear to have been transient. In trial (d) raceways fitted with a cross-flow system, either with gravel substrate panels or without, were compared with plug-flow controls. At the end of the study, fish reared in the raceways with gravel had better final weights, growth rates, and feed conversions compared with fish in the plug-flow controls. Fins were generally significantly better for fish in both cross-flow raceways compared with the controls. The results indicate that raceway substrate and design can be manipulated to reduce fin erosion when culturing rainbow trout.

Reference

BSOEU-!S/F/!(Utah Division of Wildlife Resources, Fisheries Experiment Station, 1465 West 200 North, Logan, Utah 84321, USA. E-mail: nrdwr.rarndt@state.ut.us), SPVUMFEHF-!N/E/-!XBHOFS-!F/K!BOE!NFMMFOUIJO!S/G- 2001. Influence of raceway substrate and design on fin erosion and hatchery performance of rainbow trout. North American Journal of Aquaculture, 63(4): 312–320.

16. Effect of ingredient particle size on growth and excretion

Determining the optimum grinding size of feed ingredients is important in formulating fish feeds for a number of reasons. For example the extent of grinding affects the cost of feed manufacture because finer grinding takes more effort and energy. Fine grinding is also generally thought to improve digestibility and therefore reduce the feed conversion ratio. Pilot production systems were used in this study to identify the impact of ingredient particle sizes on apparent digestibility, growth, FCR and feed waste generation in rainbow trout. The study was intended to provide not only insights into optimal fish feed manufacturing, but also information on the waste generation rate of fish fed feeds of different physical characteristics. It was found that particle size of the feed ingredients (ground using a hammer mill with 0.6 and 3.0 mm screen sizes) had no significant effect on the apparent digestibility of dry matter, phosphorus and crude protein in cold extruded diets. Feed ingredient particle size had an impact on the feed conversion ratio over an 85-day feeding trial when key ingredients (78.65% of diet) were ground using a pulverizer and a hammer mill with 3.0 mm screen size and heat extruded. No significant differences were observed in the excretion ratios of total ammonia nitrogen, total Kjeldahl nitrogen, total phosphorus, 5-day biochemical oxygen demand or total suspended solids among three feed types, which included a wide ingredient particle size distribution.

Reference

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17. A water temperature regime preventing occurrence of PKD

Initial observations of proliferative kidney disease (PKD) at fish farming sites have demonstrated that its occurrence is associated with seasonal increases in water temperature with surviving fish becoming resistant to further overt PKD. This paper reports on experiments that indicate rainbow trout which have accumulated 1300°C days (days x degrees) at water temperatures averaging 10 - 11°C (between January and April) in waters enzootic for PKD acquire resistance to the parasite and do not develop clinical signs of the disease. Trout of the same pathogen-free stock introduced into infected waters from mid May onwards when water temperatures reached 16.7° and therefore permissive for the onset of the disease contracted PKD resulting in a 60% mortality. The authors considered a further investigation worthwhile in determining the minimum number of day x degrees exposure of fish to the parasite at non-permissive water temperatures from 8 to 14°C, that would result in the prevention of overt PKD in trout farms supplied by water harbouring *T. bryosalmonae*-infected over-wintering bryozoans.

Reference

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18. Application of cryopreserved trout sperm to large scale fertilization

Pakaging of sperm in traditional 0.25 and 0.5 ml straws has been successfully applied to cryopreservation of semen of several fish species. This is useful for laboratory purposes but for applications in salmonids using 1.8 and 5 ml straws could reduce the time for packaging and sperm handling during fertilization. This paper analyses the best freezing/thawing conditions for these large straws and reports on the viability of large volume sperm cryopreservation that would be required in fertilising large egg batches in commercial hatcheries. Sperm was diluted at a 1: 3 ratio in #6 Erdahl and Graham extender with 7% DMSO, 10% egg yolk and 7.5 mg/ml Promine. Freezing was performed at different levels above the surface of liquid nitrogen using a styrofoam box and thawing was carried out in a water bath at different temperatures. Freezing and thawing rates inside the straws were registered with a thermocouple. The success of sperm cryopreservation was checked in vitro using several sperm quality parameters: motility, viability and membrane functionality. Fertility tests were also performed on small batches using a ratio of

200 eggs/ml of diluted sperm. Freezing and thawing rates were similar in 1.8 and 0.5 ml straws. However, lower freezing and thawing rates were achieved with 5- ml straws even at lower freezing and higher thawing temperatures. Motility analysis gave similar results in sperm cryopreserved in all the tested straws (0.5, 1.8 and 5 ml). However, cell viability (61.9%) and fertility (73.2%) were slightly lower in large volumes than in 0.5 ml straws (77.4% and 84%, respectively). Fertilisation of larger egg batches (1600 – 2000 eggs) with sperm frozen in 5 ml straws provided similar fertilisation rates (73%), demonstrating that the slight loss in fertility is compensated by the benefits of 5 ml straws. These results indicate that cryopreservation of large sperm volumes could be useful for commercial hatchery purposes and represent a significant advance in the preservation of salmonid sperm.

Reference

Dbcsjub-!F/-!Spcmft-!S/-!Bmmbsf[-!S/!boe!Ifssíf[-!N/Q! (Department of Cell Biology, Faculty of Biology, University of Leon, 24071 Leon, Spain. E-mail: dbcmho@unileon.es), 2001. Cryopreservation of rainbow trout sperm in large volume straws: application to large scale fertilization. Aquaculture, 201(3 & 4): 301–314.

19. Effect of dietary oils on diseasesusceptibility

Factors which predispose fish to bacterial infections is not well understood. There is a complex relationship between dietary factors and disease resistance, and although micronutrients such as vitamins have received much attention, information regarding dietary lipids is rather limited. The first objective of this study was therefore to examine how dietary lipid sources in diets given to Arctic charr influenced disease resistance during a cohabitant challenge with *Aeromonas salmonicida* the causative organism for furunculosis. Controversy also exists as to whether or not the intestine is an infectious route for *A. salmonicida* and a second objective was therefore to study the possibility of finding the bacterium in the gastrointestinal tract after challenge with the pathogen using transmission electron microscopy (TEM) and an immunogold method. Arctic charr were fed diets based on a commercial recipe supplemented with either linseed, soybean or marine oil prior to cohabitant challenge with *A. salmonicida*. Mortality varied significantly between the three dietary groups. Highest mortality (48%) was observed in fish fed the marine oil and lowest mortality (20%) was in the group fed soybean oil. TEM examination of the digestive tract of uninfected fish demonstrated substantial numbers of bacterial cells between microvilli. However, only a few bacteria were recovered that were associated with the microvilli of infected fish. Immunocytochemical staining/labelling investigations using TEM and an immunogold method were performed on mid-gut segments of fish fed the marine oil diet and showed augmentation of goblet cells and the presence of *A. salmonicida* in the gastrointestinal tract of diseased fish after challenge with the pathogen. It was suggested that the gastrointestinal tract could be an infection route of *A. salmonicida* . The greater prevalence of goblet cells supports the suggestion that sloughing off mucus is a protective response against bacterial infections. These results make an important contribution to the understanding of how nutrition can affect the disease resistance of fish.

Reference

MÂefnfm-!KC/-!Nbzifx-!U/N/-!!Nzlmfcvtu-!S/-!!Pmtfo-!S/F/-! Ftqfmje-!T/!boe!Sjohp-!F/ (Department of Arctic Veterinary Medicine, The Norwegian School of Veterinary Science, Stakkevollveien 23 b. NO-9292 Tromso, Norway. E-mail: Einer.Ringo@veths.no), 2001. Effect of three dietary oils on disease susceptibility in Arctic charr (*Salvelinus alpinus* L.) during cohabitant challenge with *Aeromonas salmonicida* ssp. Salmonicida. Aquaculture Research, 32(12): 935–945.

20. Effect of salmon farms on lice infection in sea trout and charr

The abundance of salmon lice and the physiological effects of infection were examined in two stocks of sympatric sea trout and anadromous Arctic char in northern Norway. One stock feed in a coastal area with extensive salmon farming (exposed locality), while the other feed in a region with little farming activity (unexposed locality). The results showed that the lice infection was significantly higher at the exposed locality, at which the mean intensity of infection peaked in June and July at over 100 and 200 lice larvae per fish respectively. At the exposed locality a premature return to freshwater of the most heavily infected fish was observed. Such behaviour has previously been interpreted as a response by the fish to reduce the stress caused by the infection and/or to enhance survival. Blood samples taken from sea trout at sea at the exposed locality showed a positive correlation between intensity of parasite infection and an increase in plasma cortisol, chloride and blood glucose concentrations, while the correlations from sea trout in freshwater were more casual. Several indices pointed towards an excessive mortality of the heaviest infected fish, and 47% of the fish caught in freshwater and 32% of those captured at sea carried lice at intensities above the level that has been shown to induce mortality in laboratory experiments. Furthermore, almost half of all fish from the exposed locality had lice intensities that would probably cause osmoregulatory imbalance. High salmon lice infections may therefore have profound negative effects upon wild populations of sea trout. At the unexposed location, the infection intensities were low, and few fish carried more than 10 lice. These are probably within the normal range of natural infection and such intensities are not expected to affect the stock negatively.

Reference

CKÂSO-!Q (Norwegian Institute of Fisheries and Aquacultlure, N-9291 Tromsø, Norway. E-mail: paal-arne.bjorn@fiskforsk.norut.no), GIOTUBE-!C/!BOE !LSJTUPGGFSTFO-!S/- 2001. Salmon lice infection of wild sea trout and Arctic char in marine and freshwaters: the effects of salmon farms. Aquaculture Research, 32(12): 947–962.

21. Competitive ability is related to metabolic rate

Dominance hierarchies, where individuals differ in their relative social status are observed amongst many vertebrate species and is common in fish. High status confers many benefits such as preferential access to resources, increased growth and survival and an opportunity to reach sexual maturity at an earlier age. Although the benefits of social status have been well studied the causes are less clear. However recent studies have suggested a link between metabolism and social status in which individual salmonid fish with a higher than average resting metabolic rate (controlling for body size) tend to be more aggressive and dominant over their conspecifics. This study carried out a detailed examination of the relation between metabolic rate and competitive ability in rainbow trout using size matched all-female juvenile fish. Of 55 size-matched (relative size difference <5%) trout each consisting of one high and one low relative metabolic rate (RMR) fish, the high RMR fish was dominant in 36 pairs (65.5%), significantly more often than expected by chance. The probability of a fish winning was related to its RMR (measured prior to introduction into the test arena): the higher the RMR of a fish compared to its opponent, the greater its probability of being dominant. In the 36 pairs of fish where the low RMR fish was the subordinate, its competitive ability was significantly correlated with how closely the two fish were matched in terms of their RMR. The smaller the difference between the RMR of the dominant high RMR fish and subordinate low metabolic rate fish, the greater the competitive ability and feeding success of the low RMR subordinate. However, no such relation was found in the 19 pairs of fish where the high RMR fish was the subordinate. In these pairs, the competitive ability of the subordinate high RMR fish was correlated with its size relative to its dyad partner. The larger the dominant low RMR fish, the lower the competitive ability of the subordinate high RMR fish. Thus, individual variation in metabolic rate appears to be one physiological mechanism, that could act through the medium of relative social status, to promote multiple life history variants in salmonid fishes in the wild; individuals with a high metabolism being dominant and adopting a faster life history trajectory.

Reference

NDDBSUIZ-!J/E/ (Fish Biology Group, University Field Station, University of Glasgow, Rowardennan, Glasgow, G63 OAW, U.K.), 2001. Competitive ability is related to metabolic asymmetry in juvenile rainbow trout. Journal of Fish Biology, 59: 1002–1014.

22. Fertilisation dynamics in rainbow trout

This paper examined a number of aspects of rainbow trout fertilisation dynamics potentially relevant to attempts in identifying the determinants of reproductive success of males of different age, size and status competing for spawning. First the characteristics of milt production and sperm motility in adult and precocious male trout from a natural population is described. Second the motility of sperm and the proportion of eggs fertilised by different concentrations of sperm from 'primed' adult males is compared. Third, because any differences in the time of release of gametes by females and males may be critical in determining the outcome of a competitive spawning the (a) duration of viability of sperm and eggs following activation by freshwater and (b) the speed with which fertilisation occurs was examined. There were no differences in the gonadosomatic indices and relative yields of milt of adult (3 year) and precocious (1year) male trout collected from a wild population. The concentration of sperm in the milt of precocious males was higher than that of adult males. The duration of sperm motility was similar in the two groups of males and increased over the period of sampling. Interaction of a male with a nesting female caused an increase in milt yield, but did not affect sperm concentration, sperm motility, or fertilisation rates. There was a sharp decline in fertilisation rate 20 s or more after activation of the sperm or eggs by fresh water. Exposure to mlt suspension for as little as 0.5 s resulted in fertilisation of 27% of eggs. The short gamete longevity and the speed with which fertilisation occurs indicate that the timing and position of sperm release may play a critical role in determining the reproductive success of males in competition for spawning with a single female.

Reference

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