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

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CONTENTS Page

Trout production

2004 Survey of trout production in England and Wales 5

2004 Rainbow trout egg imports into England Wales 8

Articles

British Trout Farming Conference, Sparsholt, 2-3 September 2004
Tim Ellis and Keith Jeffery 9

Investigations and enforcement of Fish Health Legislation
Stephen Maidment 13

Planning for exotic notifiable fish disease outbreaks
Ed Peeler and Mark Thrush 14

Non-native parasites in England Wales - what next?
Chris Williams, Nigel Hewlett and Adrian Taylor 16

Development of a management system for the control of *Ichthyophthirius multifiliis*
Andy Shinn, Nick Taylor and Rod Wootten 21

Moving fish? - first check the net
Caroline Crane and Ian Laing 25

Fish Health Controls: The activities of the Fish Health Inspectorate in England and Wales 2004
Richard Gardiner 27

Announcements

Urgent Press Release: British Trout Farming Conference 2005 32

Finfish News – The new name for *Trout News* 32

Guides to protecting fresh water fish published 33

Press Release: Humane killing of salmon and trout 33

Press Release: Probiotics in trout feed confer protection against pathogen and help optimise flesh quality parameters 34

Defra aquaculture disinfectant listing scheme 35

Information file

The Fish Health Inspectorate and You
Standards of Service - Citizen's Charter Performance Results
Debbie Murphy 36

BTA News
Jane Davis 38

CARD R&D update - what does the future hold?
Mark James 40

Where to get help and advice 43

Research News 44

Trout News in the News 54

TROUT PRODUCTION

2004 SURVEY OF TROUT PRODUCTION IN ENGLAND AND WALES

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Each year, the inspection and monitoring programme of salmonid farms in England and Wales is undertaken by the Cefas Fish Health Inspectorate, on behalf of Defra and the Agriculture Department of the National Assembly for Wales under the European Council Directive 91/67/EC. A total of 248 registered salmonid farm sites were visited during the first half of 2005. Of this total, there were 10 sites with no sales of fish during 2004 but which continued to hold stock. In addition two new farms were registered while nine sites ceased trading and were deregistered during the year, though some of these still reported production. The data included in this report and provided by the site owners therefore represents the production from a final total of 247 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 2004
2) Sites that produced rainbow trout for the table market only
3) Sites that produced rainbow trout for restocking fisheries and/or for ongrowing
4) Sites that catered for both table and restocking/ ongrowing markets.

The total annual production of rainbow trout for the table market in 2004 was 5,858 tonnes from 82 farm sites. This figure is a fall of almost 5% on the 2003 production (6,143 tonnes). A total of 177 farms produced rainbow trout for restocking fisheries or ongrowing purposes; this was a decrease of 1 site on the 2003 numbers. These sites together produced 3,164 tonnes during 2003, of which 2,677 tonnes were restocking trout and 487 tonnes were fingerlings or yearlings for ongrowing. This represents an increase of 8 tonnes on the total restocking and ongrowing production recorded for 2003 (3,156 tonnes). Although the recorded production of rainbow trout for the table

Table 1. 2004 rainbow trout production by Environment Agency region for England and Wales

Environment Agency Area	Number of Sites					Production		
	No Production	Table Production	Restocking/ Ongrowing Production	Both (Table & Restocking)	Total number of sites	Table (tonnes)	Restock/ Ongrowing (tonnes)	Fry (thousands)
Anglian	0	1	9	2	12	11	281	581
North East	0	4	18	9	31	1,046	506	8,732
North West	0	0	6	7	13	70	159	42
Midlands	1	0	7	0	8	0	264	0
Southern	3	4	19	5	31	1,549	156	96
South West	4	7	29	25	65	2,414	1,297	14,840
Thames	1	2	7	8	18	524	300	762
Welsh	1	1	19	7	28	244	201	2308
Totals	**10**	**19**	**114**	**63**	**206**	**5,858**	**3,164**	**27,361**

market decreased by 5% from last year and restocking production has dropped slightly, ongrowing production has increased by 25%.

The overall rainbow trout production (combining table and restocking/ongrowing figures) for England and Wales in 2004 was 9,022 tonnes, a decrease of 277 tonnes on 2003 production. In general, the data indicate that the industry is fairly stable – there are changes in the focus of production, however overall levels of production have remained fairly steady, with a decrease in total production of 3% on the previous year's level.

Table 2 provides a breakdown of trout production where farms are classified according to their scale of production. Data for brown trout are also included because the majority of brown trout are produced from sites also farming rainbow trout.

Just under 51% of the trout farms in England and Wales are in the 0-10 tonnes category but their combined output accounts for only 3.4% of total production. This is an increase from 2003 levels in both cases. The number of the smallest registered farms (0-10 tonne) has increased by 8 sites from 2003. Meanwhile the numbers of slightly larger (10-50 tonne) farms and the 101-200 tonne farms has decreased. The biggest farms (those producing over 200 tonnes annually) account for just over 46% of total trout production but form 4.3% of the total number of trout farms in England and Wales. The South West area contains the highest number of farms (73) and produces the most trout of any region (almost 43% of trout production) in England and Wales.

Production of other farmed salmonids

The 2004 production information for brown trout and Atlantic salmon is summarised in Table 3. Fry production is recorded in thousands rather than by weight as the latter measure tends to seriously under-represent the value of that production.

Of the 248 registered salmonid farms producing fish during 2004, 116 sites produced brown trout in addition to rainbow trout and 18 sites produced brown trout only (a total of 134 sites – an increase of 4 sites from 2003). Fourteen farms produced both trout and Atlantic salmon and 11 sites concentrated on producing salmon alone, while four farms failed to produce any salmon. Total production of brown trout in England and Wales has decreased to 596 tonnes (from 642 tonnes in the 2003) which includes 330 tonnes produced for the table. Six sites held brook trout (*Salvelinus fontalinus*), however, only 2 sites recorded production in 2004, a single tonne being produced for the table market and 0.3 tonnes for the restocking trade. Four sites held Arctic char (*S. alpinus*) over the period and there was a total of 9 tonnes produced for the table market.

Commercial units that supply farms in Scotland produced the majority of salmon smolts. A total of 1.9 million smolts were produced from 10 sites. This is an increase from 2003 – 1.7 million smolts from 7 sites. Five commercial sites also produced just over 177 thousand salmon parr, both decreases on 2003 data. Total production of salmon parr in 2003 was double the latest production. In addition, six Environment Agency (EA) salmonid rearing sites operated during

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 is given in brackets)

Environment Agency Area	Production according to farm output category (tonnes)				
	0-10	11-50	51-100	101-200	>201
Anglian	11 (7)	55 (3)	256 (4)	0 (0)	0 (0)
North East	39 (13)	194 (9)	247 (4)	523 (4)	597.837 (2)
North West	25 (8)	101 (5)	126 (2)	0 (0)	0 (0)
Midlands	4 (9)	113 (5)	60 (1)	132 (1)	0 (0)
Southern	58 (21)	150 (8)	0 (0)	0 (0)	1,524 (4)
South West	82 (30)	609 (25)	694 (11)	619 (4)	2,100 (3)
Thames	27 (9)	130 (5)	162 (2)	300 (2)	239 (1)
Welsh	85 (22)	128 (7)	149 (2)	105 (1)	0 (0)
Totals	**332 (119)**	**1,481 (67)**	**1,694 (26)**	**1,679 (12)**	**4,460 (10)**
% Total Production	**3.4**	**15.4**	**17.6**	**17.4**	**46.2**
% Farms involved	**50.9**	**28.6**	**11.1**	**5.1**	**4.3**

Table 3. 2004 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	8	5	30	112	1	2	330	322
North East	19	16	39	277	3	0	909	289
North West	6	4	22	81	5	3	1,224	3,523
Midlands	11	10	46	106	0	0	0	0
Southern	26	20	27	105	3	0	0	80
South West	38	24	48	1,017	2	0	5	0
Thames	11	8	34	400	3	1	29	0
Welsh	15	11	20	19	8	0	461	523
Totals	**134**	**98**	**266**	**2,117**	**25**	**6**	**2,959**	**4,736**

Plus 330 t for Table market

2004 to produce fry and juvenile salmon for specific river stock enhancement programmes. These sites together produced almost 186 thousand salmon smolts, 692 thousand salmon parr, 704 thousand salmon fry and 14.5 thousand sea trout fry. The numbers of salmon smolts produced by the EA sites has more than doubled while the numbers of fry produced has risen by 51% from last year's total. The numbers of sea trout has dramatically decreased by just over 150 thousand fry on last year's production. The changes in production from these sites suggest that the emphasis of salmon stock management is continuing a move towards the use of younger fish while maintaining the emphasis on habitat improvement programmes. The salmon fry production has increased back to the levels of production seen in 2002. The emphasis on brown trout stock management appears to be running in a cycle where juvenile fish are stocked in large numbers every other year.

Ova production

The recorded figures for salmonid ova produced over the period running from late 2004 through to early 2005 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 almost 31.7 million eggs, of which almost 15.5 million were sold to other sites. These figures represent a decrease from the 2003/04 season (36.8 million eggs). Mixed-sex rainbow trout egg production has increased to 6.1 million eggs from last year's level of 1.3 million. The recorded production of triploid rainbow trout eggs was just over 10.2 million, which is an increase from the 2003/2004 level of just under 6.5 million. Overall rainbow trout egg production has more than doubled from 19.4 million in 2003/2004 to just over 48 million for this period.

Table 4. 2004/2005 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	0	0	0	0	0	0	0
North East	21,186	1,706	1,482	107	1,307	472	0
North West	0	0	0	0	0	0	9,311
Midlands	175	0	75	0	256	0	0
Southern	145	0	543	0	275	73	0
South West	8468	4,340	3,702	239	1333	379	0
Thames	1540	0	4,440	50	1217	150	0
Welsh	140	75	0	0	211	0	220
Totals	**31,654**	**6,121**	**10,242**	**396**	**4,599**	**1,074**	**9,531**

The majority of brown trout ova produced were mixed-sex and production totalled almost 4.6 million ova, an increase of just over 1 million eggs on last years figures. Of this total almost 2.4 million were sold to other sites. A total of 396 thousand all-female brown trout ova were produced, an increase from the last reported levels – where 323 thousand eggs were produced. Triploid ova production was recorded as almost 1.1 million – remaining fairly steady compared to last year's levels. Overall production of brown trout eggs has increased. The production of triploid eggs is likely to be a continued response from the industry to the Environment Agency's stocking policy proposals, in which the use of triploids is desired as the fish are perceived to pose no genetic threat to natural trout populations. The majority of brown trout ova were produced from farm sites in the South West region, while rainbow trout ova were mainly produced in the North East.

Commercial salmon rearing sites laid down just over 9.5 million salmon eggs; this is a significant increase from 2003 levels. A further 715 thousand eggs were produced for EA stock enhancement programmes, an increase of over 400 thousand eggs from last year's levels. In addition, just under one million eggs from salmon broodstock obtained from rivers around England and Wales were laid down by commercial hatcheries, in co-operation with the EA, and reared to produce parr for local stock enhancement schemes.

2004 RAINBOW TROUT EGG IMPORTS INTO ENGLAND WALES

Rainbow trout egg imports into England & Wales during 2004 totalled almost 21 million. This is a slight decrease on the number of eggs imported in the previous year (22 million).

Table 1. Summary of rainbow trout eggs imported into England and Wales by month in 2004

Month	Northern Ireland	Isle of Man	Denmark	USA	Total
January	20,000	1,300,000	1,650,000	0	2,970,000
February	0	1,175,000	950,000	120,000	2,245,000
March	0	1,040,000	0	1,105,000	2,145,000
April	40,000	0	1,000,500	530,000	1,570,500
May	0	0	350,000	1,150,000	1,500,000
June	0	0	0	900,000	900,000
July	0	0	50,000	1,840,000	1,890,000
August	0	0	0	1,000,000	1,000,000
September	0	0	0	1,900,000	1,900,000
October	70,000	150,000	0	465,000	685,000
November	20,000	1,425,000	600,000	514,000	2,559,000
December	20,000	700,000	150,000	570,000	1,440,000
Total	**170,000**	**5,790,000**	**4,750,500**	**10,094,000**	**20,804,500**
Total %	**0.8**	**27.8**	**22.8**	**48.5**	**100**

BRITISH TROUT FARMING CONFERENCE, SPARSHOLT, 2-3 SEPTEMBER 2004

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This article reports the presentations given on the final day of last year's Sparsholt Conference. The first day's talks were covered in the January 2005 Issue of *Trout News*.

Food Safety

Mark Toal from the Chemical Safety & Toxicology Division of the Food Standards Agency (FSA) got the second day underway by talking on "*Food Safety and Trout Farming*". He started off by describing the origin and role of the FSA. In response to the increasingly number of media headlines highlighting various food safety issues, the FSA was set up by an Act of Parliament in 2000 to protect the public's health in relation to food. The FSA is best described as a food safety watchdog - protecting consumer's interests in an open, accessible and independent way. The FSA is the guardian of food safety legislation in the UK and works hard to ensure that it is the UK's most reliable source of information. Most food laws in the UK are previously agreed at EU level (EU Primary and Secondary Legislation), and subsequently implemented via national legislation, e.g. "The Contaminants in Food (England) Regulations 2003". The FSA is not a "food police" – local authority environmental health and trading standards officers fulfill the front line role.

Mark then discussed the nutritional benefits of inclusion of fish in the human diet. Consumption of fish, particularly oily fish, has been shown to reduce coronary heart disease mortality. It is thought that the long chain omega-3 polyunsaturated fatty acids present in fish may reduce irregular heart rhythms. These fatty acids have also been shown to have beneficial effects on several risk factors associated with cardiovascular disease, such as blood clotting. Eating fish is especially recommended during pregnancy and lactation, due to the elevated requirements for omega-3 fatty acids during development of central nervous systems in babies. Another potential health benefit of fish consumption is a reduced cancer risk, although this is not yet fully proven. In addition fish provide a rich source of other nutrients (minerals, vitamins, protein) necessary for a healthy diet.

When considering the consumption of fish, the FSA has to balance these health benefits with the potential adverse effects caused by the intake of contaminants such as pesticides, veterinary drug residues, other organics and heavy metals. Safety guidelines consider the amount of a contaminant that can be ingested without causing an appreciable risk to health.

In 1997 the results of a survey of pesticide residues in retail farmed trout was published. This was based on a small number (10) of samples and did find low levels of four organochlorine residues: DDT, dieldrin, gamma-HCH and hexachlorobenzene. However, it was concluded that the levels of these pesticides did not pose a threat to human health. The results of a more recent survey will be reported in the near future.

The Veterinary Medicines Directorate are responsible for the statutory monitoring of malachite green and leucomalachite green (as well other veterinary medicines) in farmed trout. The majority of samples tested for malachite green since the ban have been negative. However, a small number of positives have been recorded since 2002, when Defra made clear that the use of malachite green in farmed fish was not acceptable.

A recent *Science* article (Jan 2004) raised concern over the levels of dioxins and PCBs in farmed salmon. The FSA disagree with the conclusions of the *Science* article. In 1995, 40 samples of trout were taken and levels of these contaminants were all below the safety guidelines and therefore did not pose a threat to human health. A new survey is currently underway, and it is anticipated that current levels will be even lower than in the 1995 survey, as it is well known that there has been a decline in PCB and dioxin levels in the environment over the last 20 years.

Mark then discussed the FSA's advice to consumers on fish consumption. The FSA commissioned a report from a panel of experts on the nutritional benefits and contaminant risks of fish consumption. The report concluded that:

- The majority of the UK population do not consume enough fish, particularly oily fish (such as wild mackerel and farmed salmon and trout).
- An increase in average oily fish consumption to one portion per week (3 times current consumption) would improve public health
- Girls and women of reproductive age can eat up to 2 portions of oily fish per week (the FSA advise that pregnant and lactating women should not eat swordfish, shark and marlin due to the methyl mercury levels in these species)
- Women over reproductive age, boys and men can consume up to 4 portions of oily fish per week.

These recommendations are available on the Internet (*http://www.food.gov.uk/news/newsarchive/2004/jun/oilyfishwebcast*).

Mark also briefly appended information on new traceability legislation (Regulation 178/2002/EC, Article 18) to be introduced from 1 Jan 2005 to ensure traceability through the whole human food chain. This legislation requires that businesses

- Identify the suppliers of food, feed, food-producing animals and ingredients to their business;
- Identify the businesses to which products have been supplied;
- Maintain appropriate records and ensure that such information is made available to competent authorities on demand.

Preventing disease introductions

Alasdair Scott (Cefas Weymouth) then spoke on "*Investigations and Enforcement of Fish Health Legislation*" . The talk covered the role of the Senior Investigations Officer of the Fish Health Inspectorate and illegal imports of fish. Ed Peeler (Cefas Weymouth) then followed by discussing "*Planning for Exotic Notifiable Disease Outbreaks*". These two presentations are included as articles later in this issue.

Optimal feeding

Anders Andreasen (Biomar, Denmark) then spoke on "*The Value of Optimal Feeding*". He opened by stating that numerous factors affect growth and feed conversion ratio, which have direct effects on the production and profitability of a farm. Feeding strategy is one thing that the farmer does have control over, and by adopting an appropriate strategy farmers can improve utilisation and add value. Optimal feeding is a question of finding an appropriate combination of FCR and growth that provides a minimum of waste.

Anders illustrated that farmers are already using different feeding strategies. In Denmark the traditional aim is to minimise FCR. However, in other countries, e.g. Sweden and Finland, the aim is to maximise growth during the short summer growing season. Farmers need to address whether the nutrients and energy in the feed supplied are being used for growth or maintenance, with the aim being to maximise the use of the energy. He illustrated this point with graphs showing that as ration increases growth rate increases, but the ration for the lowest FCR is below that for maximum growth.

Anders then stated that feed tables should be seen as an average way of feeding, and feeding should be adapted to the conditions (water quality and oxygen supply). He suggested that general seasonal rules were:

- In spring with optimal water conditions and increasing temperature, feeding rate can be greater than guide levels.
- In summer feeding should be reduced in anticipation of critical water conditions (high temperature and low oxygen).
- In autumn feeding should be adaptively restricted.

Anders then gave an example of a trout freshwater reuse system. The farmer had tried to increase stocking density to increase production. However, the water inflow available restricted the total amount of food that could be fed on the farm, so increasing the density decreased the per capita feeding rate to half the optimal. As a result most of the food supplied was directed to maintenance rather than growth and therefore did not allow increased production. This illustrated the point that the farmer needs an overall farm management plan, with feeding strategy being an integral part

A farm management plan should incorporate planning of production and budgeting, and be comprised of a sales plan, plan for fingerlings, feeding strategy and choice of diet. The feeding strategy should allow for seasonality. If oxygen fluctuations are anticipated, technology will be required for aeration/oxygenation which can improve efficiency. In some cases the actual layout of the farm needs to be addressed to reduce running costs. He concluded by reporting farm trials which demonstrated that the accumulated effects of just a 2-3% better utilization of feed energy effectively saved £234 per tonne of feed, as well as reducing time to market size. He remarked that farmers should do their homework to generate intelligent feeding strategies and follow these up by monitoring the growth and FCR figures. Ultimately utilising feed for growth will lead to more profitable fish farming.

The remaining talks discussed various aspects of fish health and welfare. Lynne Sneddon (University of Liverpool) first spoke on "*Pain Perception in fish*", and this presentation formed the basis of an article in the previous edition of *Trout News*.

EU legislation

William Crowe (Scottish Quality Salmon) then talked about "*EU Fish Health and Welfare*". He started by illustrating his representational role on various committees – he is the EU advisor to Scottish Quality Salmon and the Scottish Salmon Producers Organisation, the FEAP delegate to the Council of Europe, and a member of the FEAP Fish Health Working Group. His talk then discussed his experience as the industry representative on EU Commission Working Groups on fish health and welfare.

William firstly covered the EU Working Group reviewing the Fish Health Directives 91/67 and 93/53. The remit of the Working Group is to:

- review and justify the controls on fish health grounds as they could be seen as a barrier to free trade both within and outside the EU
- simplify the Directives while taking into account the diversity of aquaculture production
- draft minimum control measures for fish diseases
- improve the aquatic health status in the EU.

The review considered the various List I, II & III diseases in accordance with EU classification, while taking into account the views of the World Trade Organisation as well as the interests of wild fish. List I diseases include EHN and EUS, with List II including SVC, VHS, IHN, BKD, *Gyrodactylus*, IPN and ISA. The proposed format for the revised Directive is a main text outlining the general principles and framework of the legislation, with Annexes containing the details. The Annexes can then be changed by Commission decision, thereby allowing more flexible and rapid legislative changes as technologies progress or disease statuses change.

The general principles of the new proposal were that each farm/establishment/transport unit should be authorised and registered by Member States and have basic management routines, records, hygiene measures, etc. A movement or health certificate – documentation of no clinical symptoms or suspicion of disease - should accompany any trade. Release into the wild should be from authorised farms only. Quarantine should be imposed for susceptible species or to determine carrier status, and ornamental fish would be included. There are hygiene requirements for transport of live fish, and fish and fish products must originate from an area declared disease free and be processed under strict conditions. Member States are required to have a risk based surveillance scheme for notifiable diseases (to allow for disease free zone status) with National Reference Laboratories using appropriate diagnostic methods. In cases of suspicion or confirmation of a listed disease, member states are required to provide notification and impose control measures such as no movement of fish, slaughter, and the implementation of contingency plans and ad hoc epidemiological measures. The annexes then provide further detail on disease listing criteria, requirements for establishing disease free status, contingency plans etc.

The review has also looked at vaccination. It was proposed that vaccination would be forbidden for List I diseases or List II where the Member State or zone is declared free. Vaccination would be allowed in infected zones and in exceptional cases Member States may be permitted to use an unauthorized vaccine. The Health Categorisation of farms was also a subject for discussion with classification based on known freedom from pathogens, surveillance and the level of biosecurity.

William then moved on to discuss fish welfare and the Council of Europe Standing Committee of the European Convention for the protection of animals kept for farming purposes. This committee is comprised of Member State representatives and observers from NGOs and Industry. The FEAP representatives were brought onto the committee after the 4th draft in 1999 to provide specific knowledge of fish and fish farming – previously mammalian and avian concepts had been extrapolated to fish. He suggested that the legislators may have been running ahead of scientific knowledge, due to pressure from welfare lobbies and Parliamentarians. In the absence of a clear scientific description of fish welfare, the industry recommendation was that water quality parameters should become a main determining factor.

The document is currently in its 15th Draft. It is comprised of sections on Biological characteristics of fish, General provisions, Stockmanship and inspection, Enclosures, Buildings and equipment, Management, Changes of genotype, Changes of physical appearance, Emergency killing, Research, and Annexes. It has been recommended that fish slaughter and transport are added to European conventions that already exist.

The annexes are species specific, but do not address different production systems. The annex for trout covers both freshwater and marine production. The annex contains tables on recommended levels for oxygen, ammonia, temperature, carbon dioxide, salinity, food deprivation, and stocking density. Specific issues mentioned for rainbow trout are biotechnology, i.e. the use of hormones in sex inversion should be controlled under veterinary supervision, and only fully trained competent personnel should conduct thermal or high-pressure shock treatment of eggs.

William concluded by discussing the important role industry has to play in shaping such future legislation. He discussed the importance of educating legislators on the differences between species and systems and that fish welfare is a complex interaction of water quality, behaviour and health. Legislators and consumers need to be convinced that welfare is already an integral factor in current farming practices. He also suggested that it is important to challenge the precautionary principle of welfare lobbyists where there is a lack of scientific data, and actually lead the fish welfare agenda rather than allowing campaigners and legislators to do so. As to the future, he recognised that three different organisations are currently proposing fish welfare standards (the Council of Europe, the European Food Safety Authority, and the OIE), and stated that FEAP will continue representing the industry.

Parasites

Two talks on parasites then followed. Chris Williams (Environment Agency, Cambridgeshire) gave a talk entitled "*Parasites –What Next?*", and Andy Shinn (University of Stirling) asked the question "*Ich: Are We Hitting The Right Spot?*". Both these talks are presented as articles in this issue.

Strawberry disease

Keith Jeffery (Cefas Weymouth) then spoke on "*Strawberry disease in rainbow trout in the UK*". The information was previously published in *Trout News* (No 37, Jan 2004) and is summarised here.

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

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

Welfare Research

The final presentation of the conference was by Jimmy Turnbull (University of Stirling) who spoke on "*Current Fish Welfare Research*". Trout welfare was brought to prominence in 1996 by the FAWC Report and pressure has continued from the UK government and the Council of Europe, as well as from retailers, pressure groups, and possibly consumers. There is therefore an increasing need to demonstrate that fish welfare is being safeguarded and there is little doubt that legislation is on the way, as shown by William Crowe's talk. Animal welfare is, however, complex and difficult to measure. Welfare is especially difficult to measure and assure in fish - simple translation from terrestrial systems does not work well, which unfortunately, many people included in legislative process do not appreciate. Welfare is perhaps easiest assessed in terms of "are the fish healthy?" and "do they have what they want?".

Jimmy then pointed out that the BTA and the UK trout industry have been very proactive and lead the way in fish welfare, as shown by involvement in the LINK Humane Slaughter and Defra Stocking Density projects. The latter project showed that density is a poor predictor of welfare and therefore a poor means to control welfare. Simple limits on stocking density are therefore an inappropriate and impractical way of assuring fish welfare. Two new BTA supported Defra funded fish welfare projects are following on from the stocking density work. These collaborative projects involve the Institute of Aquaculture (Stirling), Cefas Weymouth and the University of Bristol. A project on Water Quality and Welfare Assessment is being led by Stirling and Cefas Weymouth is leading one on Fin Erosion. The BTA have also funded a Niall Bromage Memorial PhD studentship to work alongside these projects.

The water quality project led by Stirling aims to examine the effects of water quality on trout welfare, and discuss appropriate and practical limits to protect welfare. This will involve identifying means of auditing welfare that will be of future benefit to farmers and retailers. The second project examining fin damage reflects the concern some people have towards fin damage, equating it to poor welfare. Zero tolerance of fin damage is however not a pragmatic view, and the damage needs to be put into context. This research therefore aims to identify how fin damage can be reduced. The planned work for both projects is farm-based to ensure it provides valid on-farm information to advise legislation. Jimmy concluded by thanking farmers for their past collaboration and hoped that it would continue in these new research projects.

INVESTIGATIONS AND ENFORCEMENT OF FISH HEALTH LEGISLATION

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This article is based upon a talk given at the 2004 Sparsholt BTF Conference

The role of the Cefas Fish Health Inspectorate

The role of the Cefas Fish Health Inspectorate is to prevent the introduction and spread of serious fish disease in England and Wales through the application and enforcement of fish health legislation. It includes:

- Registration, inspection and disease testing on fish and shellfish farms
- Investigation of fish and shellfish mortalities
- Licensing, inspection and disease screening of imported stock
- Provision of export documentation
- Statutory control of notifiable disease
- Enforcement of legislation.
- Investigation of illegal imports
- Advice to Defra, industry and the public.

The inspectorate employs a total of 18 people including eight Field Inspectors, an Investigations Inspector, and four licensing team staff.

The role of the Investigations Inspector

The Investigations Inspector is responsible for the preparation of detailed strategic and annual Investigation and Enforcement plans incorporating action plans, targets and relevant performance measurements. He offers advice and assistance to Defra, Cefas managers and Fish Health Inspectors in respect of enforcement matters and undertakes investigations and enquiries in respect of illegal imports, incidents of excess veterinary residues, and other offences. He also provides operational support to the field inspectors and organises and commands operations against suspected offenders. A major part of his role is to develop and maintain good working relations with other relevant government and non-government agencies and organisations including the popular angling press.

The Investigations and Enforcement strategy adopted by Cefas is based on an intelligence-led, inter agency, proactive approach to detect and prevent offences and reduce illegal imports. Strong emphasis is placed on working with the industry to educate and inform the trade and public alike of the dangers of fish disease. Its aim is to prevent offences and identify those individuals whose activities are likely to have the greatest detrimental impact on fish health.

Illegal imports - what are the threats?

Large carp and Wels catfish are in demand by anglers and fetch high prices from fishery owners keen to attract anglers to their waters. Ornamental cyprinids, imported with tropical fish also represent a threat of introducing and spreading disease.

Spring Viraemia of carp (SVC) is endemic on the continent and can kill 90% of susceptible species. The virus has been detected in several seized consignments illegally imported from mainland Europe in recent years. *Gyrodactylus salaris*, VHS and IHN are other diseases that can be passively transmitted by fish and in transport water. Illegal imports therefore pose a direct threat to all British fish stocks and the prevention of smuggling is therefore a high priority for Cefas.

The growth in the popularity of carp fishing in recent years has led to the high demand for the species which can be taken, stolen or purchased more cheaply on the continent and sold for sizeable profits in the UK. In recent years many waters in France have been purchased by British citizens and operated as fisheries to attract British anglers. It is commonly believed that many large animals originating from eastern Europe are being stocked into these and other sites and that some are being brought into the UK.

Despite continuing difficulties in preventing smuggling it is generally accepted that the number of fish being illegally imported has been significantly reduced in recent years. This has been brought about by firm and decisive action, publicity, and through the co-operation Cefas receives from other agencies and representative angling groups and the popular fishing press. Record seizures by Cefas inspectors and greatly increased penalties imposed by the courts have also had a direct impact on the trade.

On one occasion the importer of 1 tonne of live koi and other cold water ornamental species, pleaded guilty to illegally importing the fish from Italy and was ordered to pay fines and costs totalling £30,000. Another fish dealer/importer was caught illegally importing 1.8 tonnes of live carp from Belgium. He was also fined and received a sentence of 9 months imprisonment, suspended for two years. In both cases Cefas inspectors humanely destroyed the fish.

Figure 1. Photograph of the first cheque for £8,000 being presented by ECHO chairman Ian Chilcott (left) to the head of the Cefas Fish Health Inspectorate Eric Hudson (right) and Nick Beevers (centre, Plymouth University MRes. student)

The overall effect has been to reduce the market for illegally imported fish as anglers become more aware of the dangers of disease, and smugglers are made more aware of the possible consequences of their actions.

There can be no doubt that the influence of the English Carp Heritage Organisation (ECHO) has also had a significant impact on the trade. ECHO strongly supports the work of Cefas in combating illegal imports. The organisation was formed by a group of influential carp anglers, journalists and fish farmers who seek to maintain the heritage of English carp. The membership numbers approximately 1,500. ECHO has recently contributed more than £12,000 to Cefas to undertake research and development projects into KHV and what has become known as Spring Carp Mortality Syndrome. This is the first occasion when a representative angling body has donated funds to such a government project (Figure 1).

Trout farming is at risk from diseases introduced through illegal imports. Trout producers may have contact with fish dealers involved in smuggling. Any information on illegal imports of live fish could be useful to Cefas. Please contact the Investigations Inspector, Stephen Maidment at Cefas on 01305-206681. All information will be acted upon.

PLANNING FOR EXOTIC NOTIFIABLE FISH DISEASE OUTBREAKS

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The article is based upon a talk given at the 2004 Sparsholt BTF Conference.

Introduction

The UK is free of a number of the most serious salmonid diseases, notably viral haemorrhagic septicaemia (VHS), infectious haematopoietic necrosis (IHN) and *Gryodactylus salaris*. The risk of disease introduction can never be reduced to zero, however, the scale and impact of exotic disease outbreaks can be greatly mitigated by a prompt and effective response. The UK foot and mouth disease (FMD) outbreak in 2001 highlighted the importance of contingency planning for exotic diseases. Lessons for planning for exotic aquatic animal disease outbreaks can be learnt from the recommendations in reports of the 2001 FMD outbreak[1,2]. This paper outlines key elements of planning for a notifiable fish disease outbreak.

Contact chasing

Following detection of an exotic notifiable fish disease, one of the early priorities is to establish its geographic distribution. The movement of live fish to and from infected farms would be used to identify potentially infected river catchments (contact chasing). Strategies to sample farmed and wild fish populations to establish whether the disease was present are important elements of a contingency plan.

Movement controls

A key objective of contingency plans is to minimise the risk of disease spread to uninfected sites and catchments. Therefore, the development of contingency plans depends on an understanding of the routes of spread of the disease between farms and rivers. Experience has shown that live fish movements are the main route of spread of new and introduced diseases. The movement of live fish was the main route of spread of infectious salmon anaemia in the Scotland in 1998/9[3]. In Norway, *G. salaris* was spread mainly through salmon restocking[4]. Work undertaken to identify and rank all possible routes of spread of *G. salaris* between catchments in England and Wales[5] concluded that the main route of spread will be the movement of live fish, and most importantly rainbow trout (the parasite may also spread mechanically via canoes, boats and lorries moving between farms). Strict control of animal movements is, therefore, a crucial element of any contingency plan. For example, the current FMD contingency plans require a national ban on livestock movements, which would be maintained until the extent of the outbreak was determined, at which point it would be reviewed.

Biosecurity

Biosecurity is the collective term used for measures to minimise the risk of disease introduction and spread (e.g. disinfection, quarantine, prudent sourcing of stock, stock containment etc.). Poor farm-level biosecurity significantly contributed to the spread of FMD in 2001. Ensuring a high level of biosecurity on fish farms is an important element in planning for exotic disease outbreaks, as well as good management for endemic diseases. Fish farmers have an important role to play in maintaining high biosecurity standards.

Communication

Dealing with an exotic fish disease outbreak will involve a number of organisations (e.g. Defra, Cefas, Environment Agency) and other stakeholders (e.g. fish farmers, fishery owners, riparian owners). Contingency planning must include means of communication both between regulatory bodies and with fish farmers, other stakeholders and the general public. Involvement of stakeholders in the development and scrutiny of the plans will generate a shared sense of ownership and purpose and improve the chances of cooperation in the face of an outbreak.

Worst case scenario and resource allocation

A key criticism of the FMD plans in existence prior to the outbreak in 2001 was that they had not properly considered a worst case scenario or how to scale up the response beyond the worst predicted scenario[1]. Better scenario planning would have resulted in a more realistic worst-case scenario and, therefore, the State Veterinary Service (SVS) being better able to cope with the scale of the outbreak they faced in 2001[1]. Similarly, planning for exotic fish disease outbreaks must be based on worst-case scenarios and include plans to scale up the response.

Data from the Cefas – Environment Agency Live Fish Movement Database (LFMD) has been used to stochastically model live trout movements to assess the likely spread of an introduced disease over time to first detection. The worst case scenario predicted by the model was a disease spreading to 104 river catchments in a 12 month period. These results will be used to assess the resources that would be required to effectively tackle a large-scale disease outbreak.

G. salaris: a special case

G. salaris probably presents a more serious threat and greater challenge to regulatory agencies, compared with VHS and IHN. *G. salaris* causes no clinical signs on rainbow trout and it is possible that the parasite will spread undetected on infected rainbow trout. It is likely to cause serious declines in wild salmon populations in affected rivers. The only proven form of control is elimination of all fish from a catchment by chemical means (e.g. rotenone), which is potentially environmentally damaging and logistically very difficult to implement. The use of rotenone in the UK might not be acceptable and, in many catchments would carry a low probability of success.

Since *G. salaris* may evade detection for some months following introduction, it will be necessary to develop policies to minimise the risk of *G. salaris* spread in the long term. In Norway, where *G. salaris* has affected Atlantic salmon stocks on 45 rivers, stocking rainbow trout into rivers and lakes for recreational fishing was considered too high risk and has been banned and rainbow trout hatcheries cannot supply freshwater sites outside of their own river catchment. In general, stocking infected rivers with salmon increases the risk of transmission of the parasite to neighbouring catchments[6] (through salmon migration in brackish water, illegal movements of fish, or mechanically via canoes) and is, with a few exceptions, not permitted. Angling equipment has to be disinfected before reuse.

Elimination of *G. salaris* from infected rivers in the UK is probably unrealistic with the currently available control measures. Long term measures to minimise the spread of *G. salaris* from infected rivers will need to be developed as part of the *G. salaris* contingency plan. Depending on the geographic scale of the outbreak, it may be appropriate to focus resources on the protection of important, uninfected salmon rivers.

Discussion and conclusion

Government, the fish farming community and other stakeholders have important roles to play in the planning for exotic disease outbreaks. Farmers, in collaboration with their animal health advisors have a duty to ensure that their farms implement high standards of biosecurity. Government has the responsibility to ensure that notifiable disease outbreaks are appropriately tackled, but can only succeed with the cooperation of the farming community. Communication between government and stakeholders, in particular the farming community, is essential to the successful development and implementation of contingency plans. Contingency planning should not be thought of as "*...producing a written document*", rather "*….it is about putting in place the system, processes and culture to respond effectively to crises*"[1]. This is the challenge that faces Government and the fish farming community.

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NON-NATIVE PARASITES IN ENGLAND AND WALES - WHAT NEXT?

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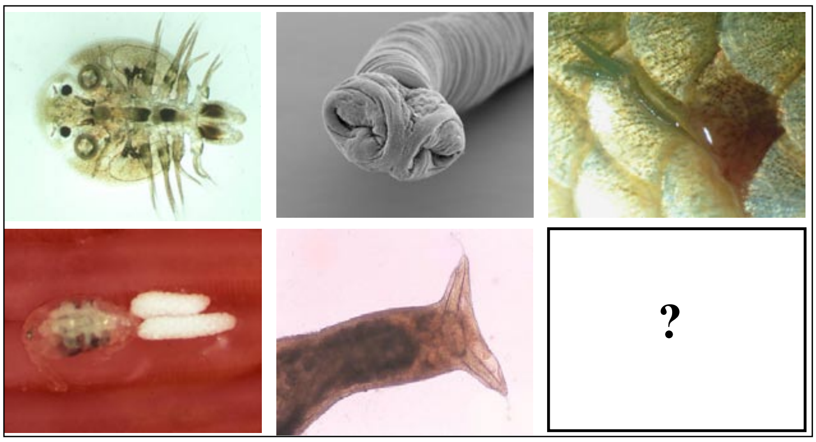

Introduction

It has long been recognised that introductions of non-native parasites can have serious and irreversible impacts upon both wild and cultured fish populations[1,2]. Such invasions have concerned fishery scientists for many years. Based upon the principle that it takes the introduction of only one pathogenic species to have a serious effect upon fish populations[1], exotic parasites must be managed with extreme caution. However, whilst a precautionary approach to species introductions represents an important component of risk management, there is also a need to balance potential impacts with other environmental, socio-economic and political considerations.

The detection, control and impact assessment of non-native parasites represent significant problems in the management of freshwater fisheries in the British Isles. Recently, the detection of growing numbers of exotic parasites has raised concern over the spread of disease to fisheries and placed increasing pressure upon government agencies with responsibility for environmental protection and fishery development. The Environment Agency (EA) regulates fishery stocking within England and Wales under its remit to maintain, improve and develop fisheries. Restrictions are placed upon the movement of fish infected with non-native parasites (Category 2 parasites) where there is a potential threat of disease spreading to wild fish populations. In order for the EA to meet its duties, there is need to balance the economic and social benefits of fish stocking against the risks of disease transfer(3). This can be extremely difficult when the pathogenicity and colonisation ability of introduced parasites are poorly understood.

Examples of parasite translocations

There are many examples of impacts caused by introductions of non-native parasites throughout the world. Some of the best recognised include the introduction of the protozoan parasite *Myxosoma cerebralis*, the causative agent of whirling disease, to salmonids in north America(4), the spread of the pathogenic tapeworm *Bothriocephalus acheilognathi* through Asia and Europe via international trade of cyprinids(5), losses of native sturgeon populations in the Aral Sea from the monogenean *Nitzschia sturionis*(6), and the decline in native Norwegian salmon stocks following the introduction of *Gyrodactylus salaris*(2). These events have raised awareness of the impacts of parasite translocations and emphasised the importance of control measures to minimise disease risks to fisheries.

Parasites and trout fisheries

Certain parasites can be highly undesirable components of trout fisheries within England and Wales, reducing economic viability and debilitating fish stocks. Whilst there is a wide range of parasites that may infect trout, arguably the most problematic in fisheries is the fish louse *Argulus* sp. Every year, the native species *A. foliaceus* and introduced species *A. japonicus* are responsible for poor catches, lethargy and even death of heavily infected trout. Another pathogenic parasite of trout is the gill maggot *Ergasilus sieboldi*. This introduced parasite was first recorded on moribund trout in Yorkshire in 1967, and has since been shown to cause considerable damage to the gills of many fish species. Heavy infections can lead to debilitation and losses of fish in both trout and coarse fisheries within England (Figure 1). This emphasises the need to not only improve understanding of parasites which are already established, but also prevent the introduction of further species which could exacerbate these problems and potentially threaten the trout fisheries industry.

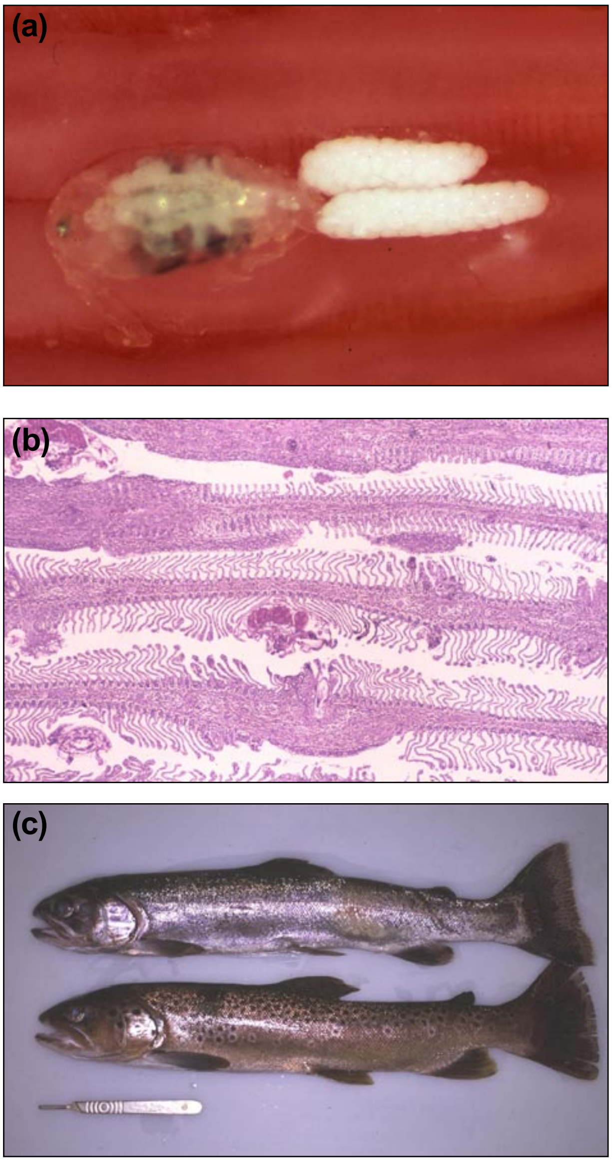

Figure 1. The non-native crustacean gill parasite Ergasilus sieboldi (a), can cause considerable damage to the gills of infected hosts (b), leading to condition loss, poor growth and mortality of many fish species including trout (b) in fisheries

The complexity of assessing impact

Not all introductions prove to be important pathogens. Non-native parasite species are not simply 'harmful' or 'harmless' but usually lead to varied and wide-ranging effects(7). These can vary from severe and acute changes to subtle and relatively benign changes. Whilst both extremes represent an 'impact' or deviation from the normal structure, behaviour or function of the host, understanding these changes and assessing their importance to fisheries overall can be extremely difficult(8). Furthermore, newly introduced parasites can take time to establish and can also adapt, exploiting different hosts or environments and changing the extent or severity of effects upon infected fish populations(9). In such cases, predicting the type and scale of impact can be problematic. This is illustrated well by the introduction of the monogenean ectoparasite *G.salaris* to Norway in 1975.

G. salaris - the danger and unpredictability of parasite invasions

G.salaris was first described from a salmon hatchery in Sweden in 1957. The parasite was not considered to be pathogenic or capable of causing disease in natural fish populations. Although exact details are unclear, it is believed that *G.salaris* was introduced to Norway from Sweden with infected salmon parr imported to meet growing aquaculture needs. Losses of salmon parr were first recorded in Norway in 1975 and involved both hatchery and wild riverine populations(2). These mortality events represented the first to be associated with the parasite in the wild(10). In the following years, the parasite spread throughout hatcheries and river catchments, resulting in more extensive and widespread disease events. In 1980, restrictions were placed upon fish movements from hatcheries in attempts to prevent further spread. Following growing concern over the threat of the parasite to the salmon fisheries industry, *G.salaris* was made notifiable in Norway in 1983(2). To date, disease outbreaks from *G.salaris* have been recorded in over 37 rivers, causing on average 86% declines in parr populations with economic losses exceeding £300 million(11).

Prior to the observed mortalities in Norway, there was little to indicate that the parasite was different from any other gyrodactylid species. This unpredictability has been realised in subsequent introductions of the parasite to other geographical localities, some resulting in further mortality events(11) whilst others have experienced no sign of disease(12). The inability to predict the impact of such introductions reinforces the need to treat invasions of all non-native parasites with extreme caution, including those that may be initially considered only weakly pathogenic. It is unlikely that all future parasite introductions will be accompanied by extensive literature, or clear examples of impacts in other localities. These less recognised threats need appropriate management if potential dangers are to be minimised and fisheries protected. The most recent addition to the parasitic fauna of the British Isles, is the monogenean ectoparasite *Pellucidhaptor pricei* (Figure 2), detected during routine EA health screens in 2001. The parasite had only previously been recorded in Lithuania and its pathogenicity is very poorly understood. Such examples are typical of non-native parasite invasions, making initial assessments of disease risk very difficult(13).

Parasite introductions within England and Wales

The introduced macroparasite fauna of the British Isles now exceeds twenty species and includes representatives from nearly all major taxonomic groups(1). This provides potential for varied impacts to fisheries and emphasises the need for careful detection effort. Most of these

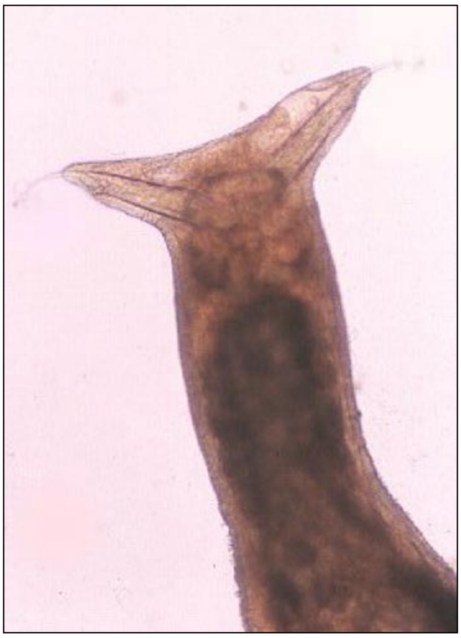

Figure 2. The monogenean parasite P. pricei – a recent addition to the parasite fauna of the British Isles. A potential threat to fisheries?

parasites have been detected within the last 30 years, and are primarily associated with the introduction of infected fish(1). Many factors are believed to have assisted the invasion of these species, including the implementation of a single European market, improved transport links and increasing demand for fish to satisfy the angling, ornamental and aquaculture industries(1,14).

In recent years, certain trends in fisheries have further increased the potential for non-native parasite introductions. The growing interest in exotic fish species for angling, in particular sturgeon, catfish and ornamental carp variants have increased the potential for introduction of equally exotic pathogens. Demand for very large specimen fish has also increased the illegal trade in certain species, where health status is often a secondary consideration to size and cost.

What are we protecting - the value of fisheries

The environmental and socio-economic value of fisheries in England and Wales is considerable. It has been estimated that angling currently contributes over £3 billion to the national GDP(15). Approximately 8-10,000 legal fish movements take place annually for the stocking of inland fisheries, comprising an estimated 8 million fish with a value exceeding £21 million(15). There are an estimated 30,000 still-waters and over 40,000 km of waterway within England and Wales, fished by almost 4 million anglers(15).

In the context of disease impact, the size and value of this industry highlights two important factors. Firstly, the introduction and dissemination of a pathogenic parasite has the potential to seriously impact upon the environmental and socio-economic value of fisheries.

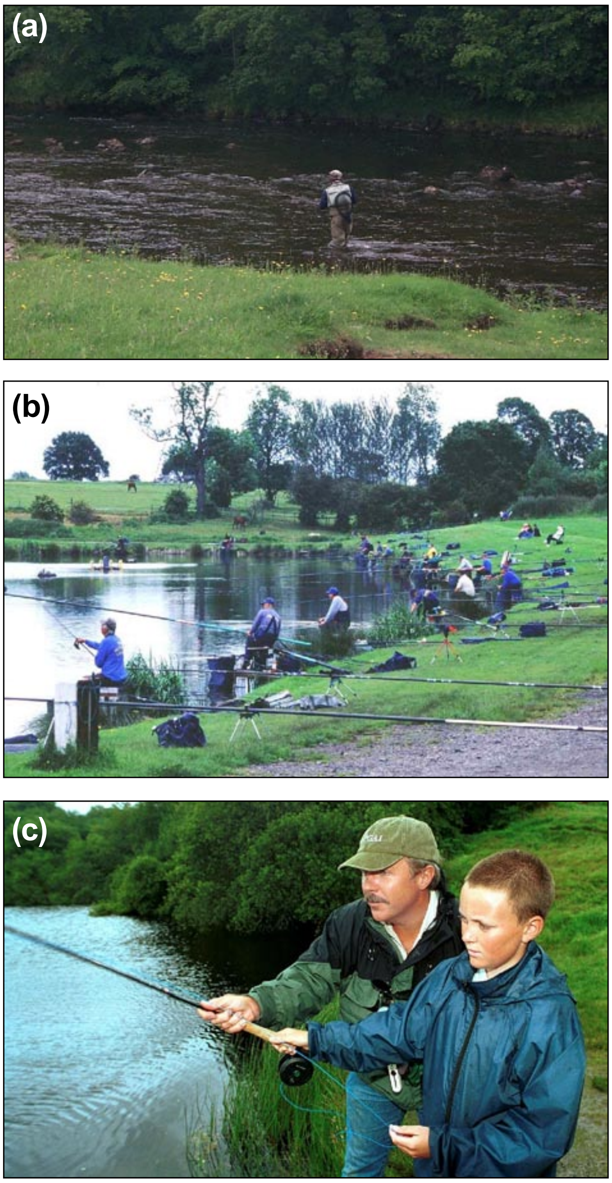

Figure 3. ***Different aspects and values of fisheries, including the environmental values of natural fisheries (a) economic value of commercial waters (b) and social value of fishing (c)***

Secondly however, control measures implemented to restrict parasite dissemination can also exert significant impacts upon the industry. As such, impacts of both parasite and subsequent control measures must be appropriately evaluated.

Efforts to overcome current problems

The EA has implemented a number of measures to improve the detection, management and control of non-native parasites and pathogens in England and Wales. This follows the detection of growing numbers of non-native parasite species, changing trends in fishery stocking activity, and a clear need to provide protection to a rapidly growing fishery industry.

1. Increased protection to trout fisheries through trout farm health checks

Health checks are risk-based procedures that aim to minimise the threat of disease transfer under legislative frameworks and with available resources. Over 600 parasitological examinations and disease investigations are undertaken annually by the Environment Agency, to monitor disease outbreaks in fisheries and identify non-native species introductions. Fish showing signs of clinical disease or infected with either Category 2 parasites or novel previously unrecorded species are restricted from movement.

Prior to 1st April 2005, EA health checks were conducted on fisheries and cyprinid farms within England and Wales, where fish were being stocked to open water bodies. The EA did not check trout farms, which were inspected by Cefas (Centre for Environment, Fisheries and Aquaculture Science) for notifiable diseases only. However, such parasite health checks have now been extended to trout farms following growing concern from the trout fisheries industry of introduction of exotic species. This not only offers the same level of protection to trout fisheries as cyprinid fisheries, but also increases understanding of the health status of all fish farms and puts into place a more robust framework for the detection, management and control of introduced parasites that may pose a threat to fisheries.

These decisions followed consultation with the Association of Stillwater Game Fishery Managers (ASGFM), British Trout Association (BTA) and Cefas. The Cefas Fish Health Inspectorate have been contracted to do this work, and parasitological examinations are to be undertaken during routine annual inspections for the notifiable diseases. The aim is to minimise disruption to farmers and the number of fish sacrificed during each visit. These additional health checks for trout farms came into effect from the 1st April 2005 and will be needed to support all fish movements where fish are to be stocked into open waters. This allows fishery owners to purchase fish with more confidence of health status and provides a mechanism for quicker detection of non-native species introductions that may not be covered by notifiable disease controls.

2. Closer monitoring and improved efficiency of national fish movements

In order to minimise the risks of exotic parasite introductions and dissemination, there is a clear need to closely monitor fish movement activity. This is currently managed through the Live Fish Movement Database (LFMD), a co-funded project between the EA and Cefas. LFMD is a single, live and interactive database, shared between government agencies e.g. Defra, Cefas, EA and NAWAD. This was designed to allow better control of undesirable and non-native species and stop the spread of fish disease. The EA is currently developing this system further to facilitate more attention to high risk fish movements and provide a faster and easier system for consenting low risk fish stocking for those involved in the fisheries industry.

3. Better awareness of the parasite fauna within the British Isles

It can often be difficult to distinguish between non-native species and those that are native yet have a sparse or localised distribution. To improve understanding of currently established species within England and Wales, the EA & Fisheries Society of the British Isles have funded research through Kingston University, to establish and update the parasite fauna of the British Isles. This will involve development of an active and comprehensive database to assist with the identification of parasite species and help establish the status of future invasions. This ongoing project will improve detection, identification and awareness of parasites within England and Wales.

4. Better impact assessment of current and future invasive species

Historically, the control of many Category 2 parasites has been based strongly upon a precautionary principle. Whilst the introduction of any exotic species must be managed with caution, prolonged reliance on this approach can hinder effective evaluation of impacts and makes it difficult to balance risks of disease against other factors. Research funded by the EA through the University of Stirling is underway to improve understanding of impacts caused by current Category 2 parasites and thus ensure effective and appropriate control measures. This work is also designed to develop a structured approach for the management of future exotic species introductions.

5. Better controls on exotic pathogen introductions from outside of England and Wales

The largest threat posed to fisheries in England and Wales, is from fish introduced from outside of the UK (e.g. many cyprinids are imported annually from various parts of the world). In order to provide better protection to fisheries from future invasive parasites and pathogens, the EA has raised health check requirements on fish introduced into fisheries from sources outside of England and Wales. All introductions of imported fish into fisheries will now be subjected to more detailed health checks including parasitological examinations for non-native species. Collaborative work with Cefas has also been undertaken to improve detection methods for, and controls of, emerging viral pathogens like Koi Herpes Virus (KHV).

Summary

The control and management of exotic parasite species will always require a risk-based approach. Non-native parasites will continue to be introduced and must be managed according to available resources and within legislative boundaries. Unless eradication is realistic, which in many extensive fisheries it is not, controls must involve raising awareness, improving detection, closer management of fish movements and better understanding of invading species. Such measures will always require an evaluation of impacts against the socio-economic and environmental benefits of fisheries and fish stocking. With increasing interest and demands for fish to stock fisheries, the management of introduced species will continue to be an important area of fishery management. The questions of what species will be next, or what is here but has so far evaded detection, represent serious issues for fisheries and fishery development.

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DEVELOPMENT OF A MANAGEMENT SYSTEM FOR THE CONTROL OF *ICHTHYOPHTHIRIUS MULTIFILIIS*

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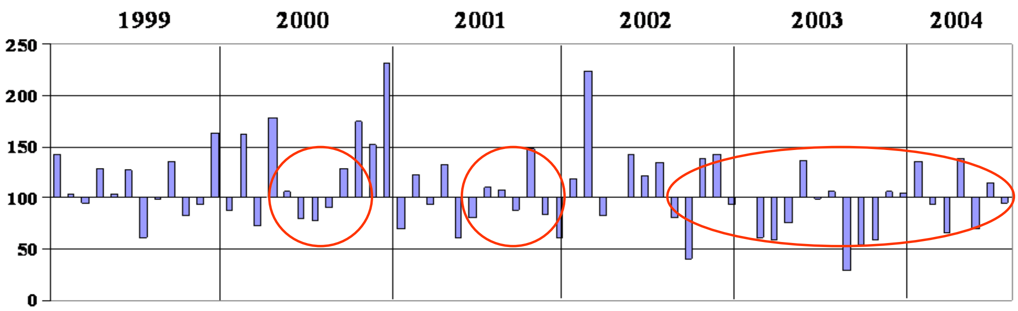
Introduction

The protozoan parasite *Ichthyophthirius multifiliis*, “whitespot” or “Ich” is a major cause of mortality in the UK trout farming industry. The parasite sits within the epidermis of a fish and causes mortality through osmoregulatory and respiratory shock when it exits the fish to encyst and proliferate. Over 60% of UK trout farms suffer problems from the parasite and at present there are few measures that can be taken to control infections. Novel control strategies and a clearer understanding of parasite dynamics in farm environments are urgently required in order to develop an effective programme of management. Over the past 12 months, research at the Institute of Aquaculture has focused specifically on the parasite’s biology and infection dynamics in conjunction with the efficacy of various husbandry measures. The information from these studies, which have also included the testing of novel in-feed nutricitical compounds, have been gathered together to propose a strategy to minimise the occurrence and impact of *I. multifiliis* outbreaks on British trout farms.

Population dynamics of *Ichthyophthirius multifiliis* in farms

Climate: Analysis of farm data sets reveals that *I. multifiliis* is responsible for between 17% and 31% of the total observed mortality. Heavy *I. multifiliis* infections are strongly correlated with high water temperatures and low rainfalls. This is illustrated in Figure 1 which displays Met. Office rainfall data for the



Year	1999	2000	2001	2002	2003	2004*
Av rainfall %	+11.17	+20.25	-3.33	+18.17	-16.50	+4.25
Av summ temp °C	+1.17	+0.57	+0.60	+0.90	+1.68	+1.10
Ap-Jn rainfall %	+19.33	+21.67	-8.33	+21.33	+3.67	+7.33
Ju-Sept rainfall %	-1.33	-17.00	+2.00	-15.00	-36.67	-5.00*

***Figure 1.** Met. Office monthly rainfall levels for 1999-2004 as a percentage of average levels during the period 1961-1990 (i.e. 100%). Circles indicate periods of high I. multifiliis induced mortality. *Based on figures up to July 2004*

last six years and highlights the particularly bad years for fish mortalities caused by *I. multifiliis*. The data shows that serious outbreaks occurred in years where the rainfall was less than the average (i.e. under the 1961-1990 average of 100%). For example, rainfall was low throughout the winter of 2002, which continued into 2003 when the worst outbreak of *I. multifiliis* in recent years occurred, causing up to 5% mortality in over 60% of British trout farms.

Transmission: One important question in trying to develop a control strategy is to establish whether infections on farm sites arise from a massive influx of infective stages from connecting water supplies or whether they are a result of multiplication of the parasite within the farm system. To determine this, *I. multifiliis* infections were followed on two populations of fish from mid-April until July 2004; one population of fish in a hatchery raceway and a second in a cage placed in the inlet channel supplying the farm. Fish were sampled every two weeks and the results are shown in Figure 2.

The results show that infections in raceways rise from 0.8 trophonts per fish on 47% of the fish in early May to 76.5 trophonts per fish on 100% of stock by the end of June. In contrast to this, no *I. multifiliis* were observed on the fish in the inlet channel until the end of June when 16.7% of the fish were observed to have an average of 0.3 trophonts per fish. These data suggest that infection in a farm site most likely results from on-site multiplication and not from a massive invasion of theronts entering the site via the water supply feeding the farm. Initial infections, however, can result from either a small number of infective theronts borne on the incoming water supply "seeding" farm infections or can be triggered by over-wintering parasites within the farm held stock.

Parasite development: To provide farmers with further details on the parasite development times, it was necessary to calculate the time taken for exiting tomonts to encyst and produce infective theronts at a range of temperatures. Laboratory experimentation showed that cysts survive at low water temperatures developing slowly (e.g. taking ~5.4 days at 4°C to produce and release its theronts). Matthews (1994) showed that development of the parasitic trophont stage at 3°C can take up to three months before it exits the host. This demonstrates that infections can persist over the winter months, but occur at such low levels due to their slow development rate that infections may go unnoticed. These over-wintering parasites act as a reservoir of infection and are likely to be the cause of the initial "visible" infections in a site once the water temperature rises. As the temperature rises, however, so does the speed of development; at 22°C it only takes ~27 hours for the cyst to develop and release infective theronts. The parasitic trophont also develops quickly at these higher temperatures taking only ~5 days to reach maturity and exit the fish.

In addition to determining the speed of cyst development under a range of temperatures, little was known of the parasite cyst's ability to tolerate and develop in a range of pHs. Trials demonstrated that tomonts raised in pH 4 to pH 10 water were able to encyst and develop to release theronts. Development was fastest at pH 7 (ca. 24 hrs at 15°C) but slowed with an increase or decrease in pH to ca. 52 hrs at pH 5 (15°C) and ca. 44 hrs at pH 10 (15°C).

Assessing husbandry practices

Water treatments: There has been growing concern within the industry as to the effectiveness of treatments for *I. multifiliis* and the possible build up of resistance.

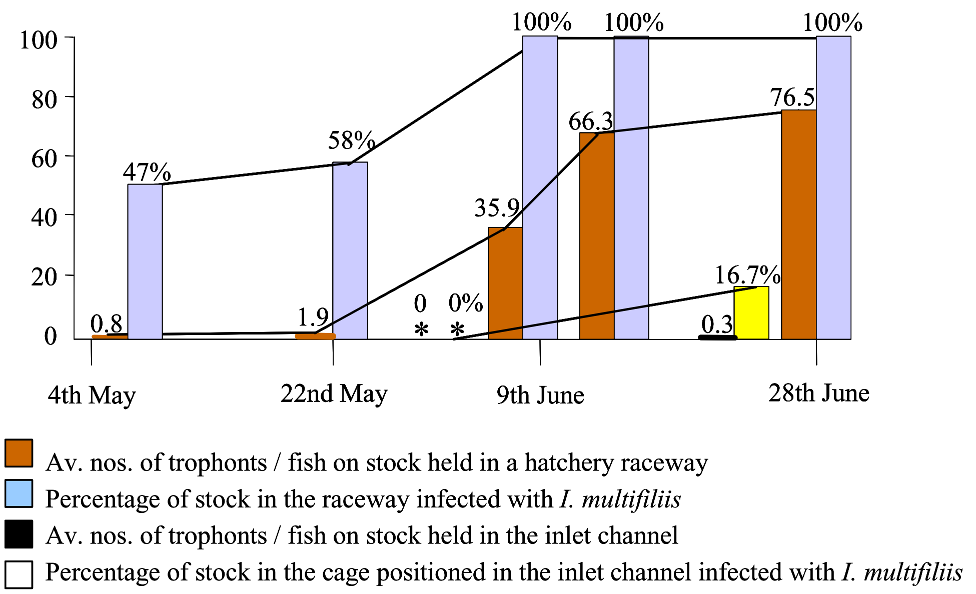


Figure 2. The infection dynamics of I. multilfiiis on fish held in a cage in the inlet channel feeding a commercial hatchery and on fish within raceways within the hatchery

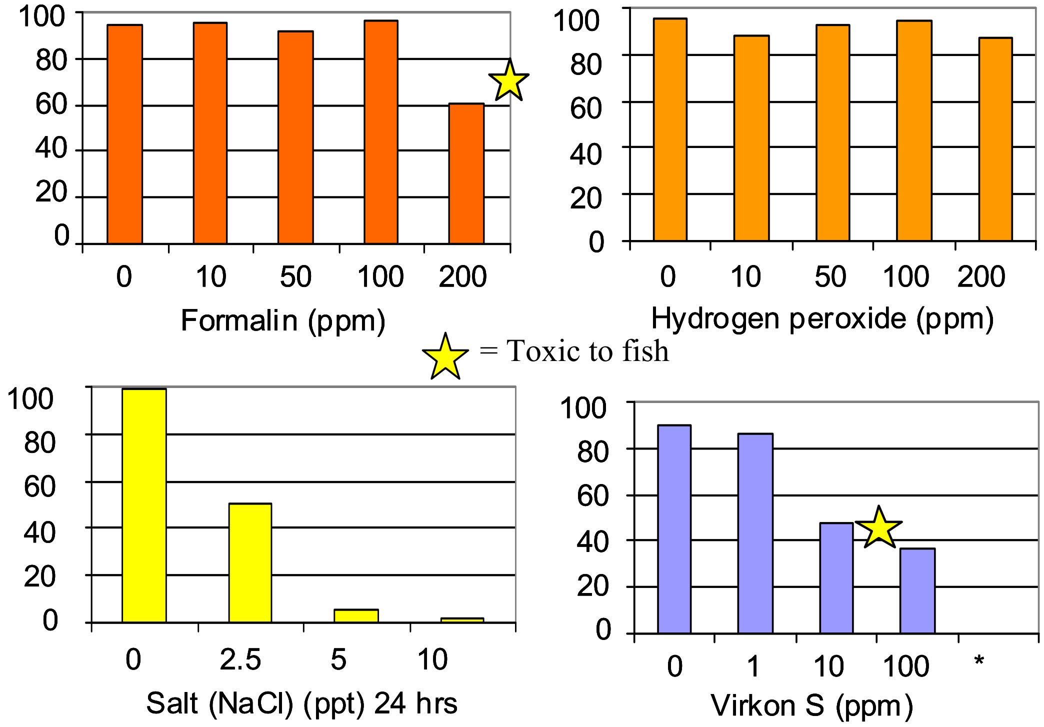


Figure 3. The percentage of theronts remaining alive after a one hour exposure (unless otherwise stated) to a range of chemotherapeutants

In vitro trials were conducted to assess the efficacy of formalin, hydrogen peroxide, salt and the disinfectant Virkon S™, among many others, as bath treatments against the infective theront stage of the parasite. Trials with two of the most commonly used treatments, formalin and hydrogen peroxide, had little effect on the parasite when used as a one-hour bath (Figure 3). At 200 ppm formalin, the maximum dose that can safely be used on fish, less than 40% mortality was observed in the free-swimming theront population.

Salt proved very effective with circa 95% theront mortality occurring when used at 5 ppt over 24 hours. This has potential as a safe, cheap and effective control measure if it can be either trickle fed into a raceway over a period of time or used in a recirculation system. The main limitation with salt, however, will be the ability to handle the quantities required. The use of other water treatments such as Virkon S, require further investigation. Trials with a dose of 1 ppm had very little impact on theronts over a one-hour period, but it may be effective if used for longer periods. A clear dose response was seen with a theront mortality of 50% observed at 10 ppm.

In-feed treatments: Nutriciticals are bioactive chemical compounds that have health promoting and disease preventing properties. A trial was conducted to establish whether three different blends of nutriciticals impacted upon the burden of *I. multifiliis* when used to top-coat a commercial pellet feed. A 7-day treatment with Citrocide and CompQ (name withheld) reduced burdens of *I. multifiliis* (Figure 4). In a second trial, fish that had received a 10-day course of 0.32% SalarBec medicated feed prior to exposure to theronts of *I. multifiliis* had a 65% reduction in the number of trophonts on fish.

Water flow: Low levels of *I. multifiliis* infection have been observed in systems with high flow rates. As part of the management system, it was suggested that if we could determine the swimming speeds of the exiting tomont and infective theront this would then allow us to calculate the minimum water velocities possibly required to disrupt normal swimming behaviour and flush parasite stages from the system. Using image analysis software, the fastest recorded swimming speeds of the two stages were determined as 3.3 mm/s (tomont) and 0.2 mm/s (theront). Using the fastest speed and adding on 10% to disrupt the fastest swimmers, a minimum water speed of 3.7 mm/s could therefore disrupt the parasite's settling, host-seeking and infection processes. Water levels should not, however, be dropped in summer months to obtain the faster water speeds as this only serves to concentrate hosts and parasites together. This aspect of management, however, requires further work to look at the relationship between water speed, stocking density and infection success.

Brushing: Hatchery raceways are currently brushed several times per week. As exiting tomonts can settle and release infective theronts in 1-2 days depending upon the temperature of the water (15°C-22°C), if brushing were to have an impact, it would have

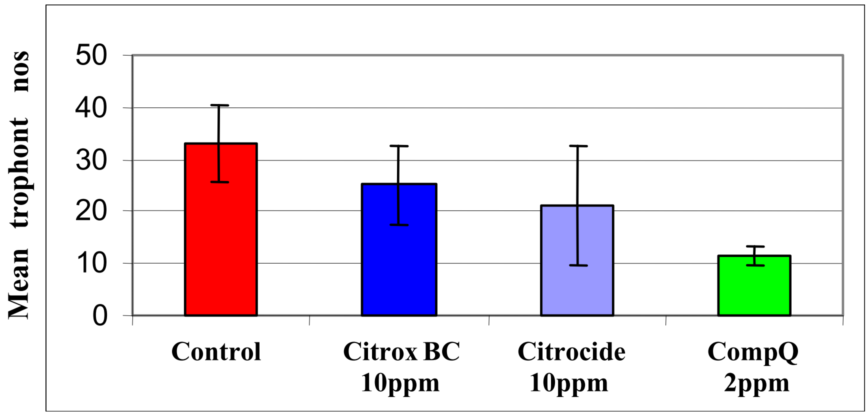


Figure 4. The average number of trophonts per fish following a 7-day regime of medicated feed prior to exposure with theronts of I. multifiliis. Each trial was performed in triplicate against a set of three controls. The trial gave statistically significant results: Control vs Citrocide P=0.032; Control vs CompQ P=0.001

to performed daily during periods of high water temperature (at 22°C cysts develop and release theronts in 26 hours) to disrupt the development of cysts. The efficacy of daily brushing in destroying developing cysts was also questioned. Although this was difficult to evaluate *in situ* on a farm site, an indication of brushing efficacy can be extrapolated by taking latex impressions of the concrete forming raceways. Figure 5 shows latex impressions of the concrete lining raceways taken from two commercial farm sites.

Given that a large mature cyst is approximately 1 mm in diameter, the latex impressions of the concrete suggest that there are numerous refugia for cysts to develop in; these would remain untouched during the process of brushing. This suggests that a single pass of the raceway with a brush would only remove a fraction of all the cysts developing in the raceway. If brushing raceways is to form part of a management system for the control of *I. multifiliis*, then it is recommended that either raceways are skimmed to give as smooth a finish as possible or are lined so that the brushing action is more likely to disrupt cysts attached to the bottom of the tank. The use of biological agents such as BiocareTM to clean raceways requires further investigation. While they may be effective in removing or killing tomonts/cysts in the cleaning process, as tomonts continually exit the host and encyst, treatments would have to be deployed daily to effectively reduce cyst numbers. The accumulative effects of such a treatment on the fish would, however, have to be determined before such a strategy is recommended.

Recommendations

Information obtained from the last 12 months research can allow us to make the following recommendations in order to prevent and minimise the impact of *I. multifiliis* infections.

Prepare for periods of hot weather and low water flows as these conditions are strongly correlated with problem infections. If possible stock density should be reduced and flow rates increased in order to disrupt the infection success of the parasite. Water levels should not be dropped in order to increase water turnover through a system as this will crowd hosts and is likely to facilitate transmission of the parasite. Increased aeration will not

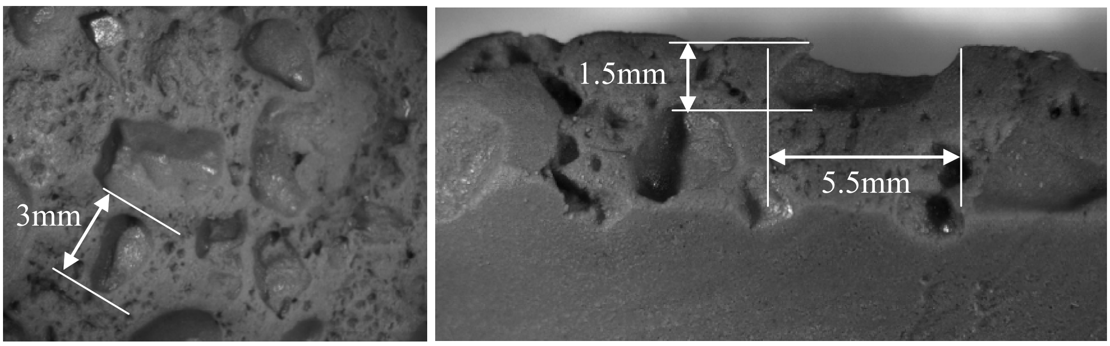


Figure 5. Latex impressions of raceway concrete, showing the size of refuges in which I. multifiliis tomonts could potentially encyst

only allow fish to tolerate low levels of infection better, but may also aid in reducing the infection success by creating turbulence and disrupting the parasite's normal swimming behaviour. Re-circulation of water will increase infection levels as this permits a greater contact time between parasite and host unless some form of filtration can be used between "water cycles" to remove or destroy infective stages.

The analysis of farm data sets showed that mortality attributed to the parasite is most likely to occur in small fish of <5 g. It is therefore recommended that management is targeted at hatchery units and that these receive periods of fallowing or are dried or disinfected between batches of fish to ensure that there are no more parasite cysts remaining in the system before new stock are introduced. A regular and frequent examination program, even throughout the winter period, is critical in order to identify problems before they start, as the parasite is much easier to manage in the early stages of infection. Hatchery units should try to use as pure a water source as possible to minimise the number of infective theronts entering a hatchery unit. The stocking densities used on farm sites are likely to aid the transmission dynamics of the parasite with low numbers of theronts rapidly leading to high infection levels within a short period of time when water temperatures are high. Second use water should never be used to feed hatchery units. Staff must be confident in identifying the parasite especially when small; good husbandry is obviously crucial. There should be no transfer of equipment between tanks and rigorous disinfection and biosecurity protocols should be developed and enforced. Brushing raceway bottoms, removing biofilms and flushing raceways may help remove tomonts and cysts from the system, however to be effective this should be conducted on a daily basis. To increase the effectiveness of brushing, raceways should be skimmed in order to provide a smooth surface that provides little refuge for the parasite. The use of compounds such as Biocare to remove organic debris may also help to remove tomonts and cysts from the system, however their regular use and impact on fish epithelium needs to be determined.

Treatment should be conducted in the early stages of infection, and the impact of treatments on the parasite population should be monitored through screening. An integrated approach should be taken, combining husbandry practices, in feed and bath treatments. Trials have shown that currently used chemicals such as formalin have little or no effect on the feeding trophont stage of the parasite, and little effect on the free-swimming stages. Due to the continuous release of parasites from their hosts when infection levels are high, long term, continuous, low dose treatments are likely to be the most effective targeting the external parasite stages (tomonts, cysts and theronts). Where short bath treatments only are possible, they should be repeated regularly over a period of days, preferably alternating between treatments to reduce the build up of resistance.

In feed treatments have several advantages over bath treatments. They are relatively environmentally friendly, easy to administer and they target stages of the parasite on the fish. Recent work at Stirling has identified several compounds that look promising as in feed treatments but further study is required to be assured of their effectiveness before the manufacturers will release their names.

Acknowledgements

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MOVING FISH? – FIRST CHECK THE NET

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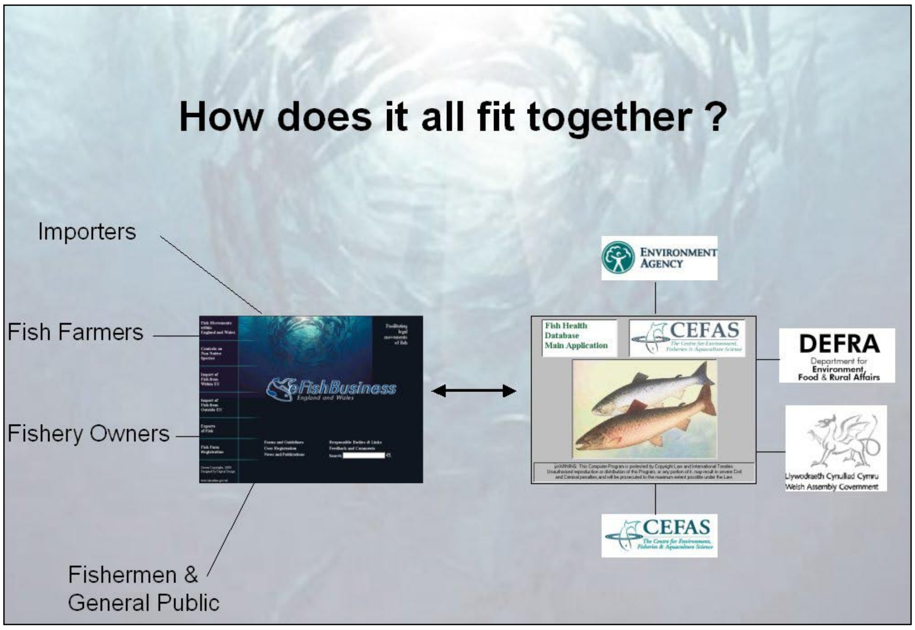
Background

In January 2001 all the related information on the controls that apply to live fish movements in England and Wales was put together, for the first time, in one place. This was achieved by setting up a website, called eFishBusiness (http://www.efishbusiness.com), on the Internet. The project to set up this website was a joint venture, involving Defra, the Welsh Assembly Government, Cefas and the Environment Agency. Funding came from the Treasury, under the ISB (Invest to Save Budget) initiative.

Information on line

On eFishBusiness you can find all the rules for all categories of fish movements, including those within the UK, within the EU and those with the rest of the



world. Information can be found covering movements both to and from fish farms and inland fisheries and those applying to the keeping of non-native fish.

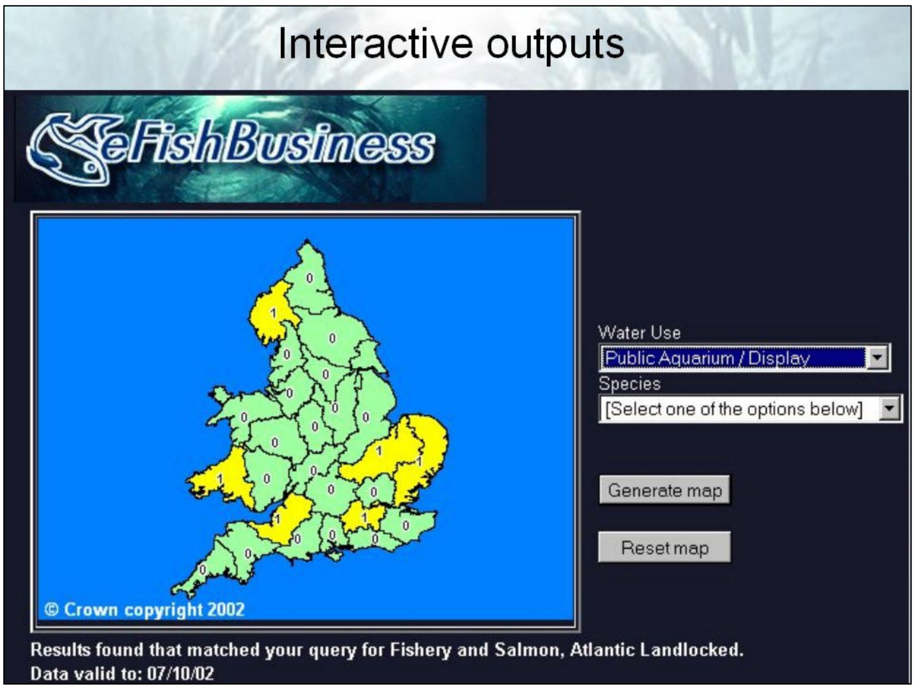
The site is organised to ensure that the relevant information is easily obtainable. It is designed such that importers, dealers, fish farmers and fishery managers can all download the various application, registration and notification forms that they need direct from the eFishBusiness site. There is a search facility to help navigate the site. And if you cannot find what you are looking for, or you are not clear on any of the rules, then there is an enquiry form that can be completed and submitted for further information. This facility also gives you the opportunity to tell us what you think of the site.

Links

Further information may also be obtained from the links to the website of the government bodies and agencies responsible for the various controls. For example, there are links to the CEFAS web site and to the Environment Agency's fisheries pages. The site has further links to the web sites of the fish trade associations

More than just the rules

As well as providing information and guidance on the legislative controls that apply to the live fish trade in England and Wales it provides background to how



these controls are intended to prevent the introduction and control the spread of serious fish diseases. A stakeholder's area of the site, which is free to registered users, provides access to supporting information, including detailed descriptions of the most serious fish diseases and datasheets on some of the non-native species covered by legislation. Species currently covered include grass carp, topmouth gudgeon, bitterling, sturgeon and pumpkinseed. This list will be added to as datasheets on other species are completed. In addition, it will soon be possible to generate reports, in the form of a map, showing where in England and Wales these non-native fish species are to be found. On-line registration on the eFishBusiness website takes just a few minutes to complete.

There are also pages covering the latest news releases that are relevant to businesses involved in moving and trading in fish. These news pages are also used as one means to inform the industry of recent and impending changes in legislation.

A frequently consulted site

The eFishBusiness website is in regular use, with an average of over 8,000 user sessions per month, an increase from less than 6,000 a year ago. Most access is from the UK and Europe, but overseas connections are also made and we suspect that this could well be for information on third country import/export legislation.

Live Fish Movements Database

The Treasury funding that helped set up the eFishBusiness website also provided for the development of an interactive database to assist the responsible government bodies to share their data electronically, where appropriate. The Live Fish Movements Database was activated in 2002. The sharing of information on *all* movements of fish has since provided an opportunity for more effective monitoring and improved enforcement measures by both Cefas and the Environment Agency across the whole of England and Wales. It has assisted us in preventing and detecting offences of fish thefts and illegal imports, bringing us ever closer to our shared objectives of protecting fish, protecting the environment, preventing fish disease, and reducing fish-related crime.

FISH HEALTH CONTROLS: THE ACTIVITIES OF THE FISH HEALTH INSPECTORATE IN ENGLAND AND WALES 2004

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Introduction

Since 1996 the work of the Fish Health Inspectorate at Cefas Weymouth has been documented annually in *Trout News*. The aim of the following report is to give fish farmers feedback on how the individual inspections we carry out on their sites relates to the overall programme of inspections on fish farms in support of the fish health regime in England and Wales.

This report provides an update of the Inspectorate's work during 2004, showing how it performed with respect to the targets set in each area of its work and outlining the current status of notifiable diseases of fish in England and Wales.

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

Inspection programmes

Details of the number of inspections carried out in each area of the Inspectorate's work are shown in Table 1. The fish health-monitoring programme on salmonid farms is based on EU requirements for the maintenance of Approved Zone status for IHN and VHS, and an assessment of disease risk associated with farming practices.

In May 2004 following negotiations with the EU Commission the UK was granted additional guarantees with respect to the List III diseases Bacterial Kidney Disease (BKD), Spring Viraemia of Carp (SVC), and *Gyrodactylus salaris* (GS). The effect of these additional guarantees is in some cases to tighten up national control arrangements, and enable equivalent controls to apply to imports of live fish of susceptible species to help safeguard against the introduction of BKD, SVC and GS.

Table 1. Number of tasks, by category, undertaken by the Fish health Inspectorate in 2004

		Site Type	
	Salmonid	Coarse	Total
Farm Inspection (No samples)	240	154	394
Routine sampling and inspection	108	0	108
Inspection and sampling on suspicion	9	4	13
Notifiable disease re-tests and contact tests	2	22	24
Reported disease outbreaks & mortality investigations	11	159	170
Import checks : Sampling	9	71	80
Import checks : Inspection/physical checks	1	42	43
Export Certification	7	40	47
Site Disinfection Visits (* - *3 Eel site disinfections)*	0	7*	7
Wild Fish Monitoring	0	0	0
Other†	1	176	177
Collection of Veterinary Medicine Residue samples	101	0	101
Category II Parasite testing	75	0	75
		Total	1239

† includes ILFA visits, collection of research samples, checks on quarantine facilities and registration visits

All registered salmonid farms were visited in the spring, with all sites holding broodstock or operating hatcheries, receiving a second inspection during the autumn. Samples for IHN and VHS were taken from approximately half of these farms as part of a two year rolling programme, which ensured that the necessary work in support of the maintenance of our Approved Zone status was completed to the required standard. However, in the future, samples of kidney tissue will be taken routinely from 30 fish to test for BKD. This will be done every second year, wherever possible at the same time as the VHS and IHN samples are collected.

In addition to this routine monitoring, samples were taken on farm sites where inspectors observed signs of disease in fish, or where farmers reported disease problems to us. Only 20 such samples for notifiable diseases were taken in 2004, again down on the previous year. None of these investigations confirmed the presence of any notifiable disease.

In 2004, following consultation between the Environment Agency, the Association of Stillwater Game Fishery Managers, the British Trout Association and Cefas, the Environment Agency extended its Category 2 Parasite Health Check regime to include salmonid farms. The Fish Health Inspectorate were contracted to carry out parasitological examinations during their routine inspection duties. These additional health checks on salmonid farms came into effect from the 1st April 2005 and will be needed to support all fish movements where fish are to be stocked into open waters. These health checks were spread across 2004 and 2005 with 75 health checks completed by the end of the year, and the rest completed by 1st April 2005.

The Inspectorate is also contracted by the Veterinary Medicines Directorate to collect samples of farmed fish for veterinary residue testing. A total of 101 samples were collected from salmonid farms, with an additional 11 samples taken during follow-up investigations. These follow-up samples were taken from two farms after the detection of residues of malachite green or leucomalachite green in samples taken in autumn 2003, and from a third farm following an act of vandalism in which old stocks of malachite green where dumped into the farm ponds.

The inspection programme for coarse fish sites during 2004 involved a single visit to each farm site, to assess the health of the fish stocks, and to check movement, mortality and medicine records. In the future, following the granting of additional guarantees for SVC, farms and establishments (other than retail premises) holding susceptible species will also have a sample of 30 fish tested every second year for SVC.

In addition, the programme of import checks on consignments of SVC susceptible species coming from non-EU countries was maintained. As a result a total of 113 consignments were inspected, with 71 sampled, from all of the major countries supplying such fish. All tests proved negative for SVC.

The Inspectorate also investigated 159 mortality events in coarse fishery waters and in sites holding coldwater ornamental fish during the year. Two coarse fishery sites tested positive for SVC and were subject to Designated Area Orders for this disease. The decrease in investigations of mortalities in coarse and ornamental fish was possibly associated with a better understanding within the industry and the general public of Koi Herpesvirus (KHV).

The status of notifiable diseases in England and Wales

VHS and IHN. All registered farm sites continue to test negative for these List II viral diseases, as did all samples of fish from UK sources. None of the reported disease problems or samples taken on suspicion proved to be positive for these diseases.

BKD. There were no new cases of BKD identified in 2004. At the beginning of the year only 3 sites remained designated for the disease. None of these sites are currently operational farms, and the absence of disease was demonstrated at two of these sites and so the statutory controls were removed. There are therefore no active sites designated for BKD in England and Wales and it is expected that the remaining DAO will be lifted in 2005*.

IPN. All salmon farms continue to be tested annually for IPN, and in 2004 all sites tested negative in England and Wales. There are no farms subject to movement restrictions for this disease. As the UK application for additional guarantees for IPN was not approved by the EC, fish farms in England and Wales that require IPN testing in 2005 will have to arrange for testing to be carried out on a commercial basis.

Gyrodactylosis. All salmonid samples from farms or wild environments were screened for *G. salaris* and none was found positive. As in previous years two other species of gyrodactylid were found on salmonids; *Gyrodactylus derjavini* on both rainbow and brown trout, and *Gyrodactylus truttae*, primarily on brown trout. Levels of infection were never at intensities likely to cause heath problems for the fish.

SVC. SVC was isolated from fish stocks on 2 commercial coarse fisheries, which appeared not to be linked and follow up investigations and contact testing failed to identify the source of the infections. Statutory controls were placed on both sites.

SVC was also isolated from 3 ornamental businesses (4 sites) in 2004. The disease outbreaks at three of the sites appeared to be linked and supervised clearance and disinfections programmes were completed on all four sites.

Re-testing for SVC took place on 8 infected sites in 2004, all tested negative for the disease and the DAO was subsequently removed from one site following three years of negative testing. At the end of 2004 there were 9 sites designated for SVC in England and Wales.

Emerging diseases

Candidatus (Summer Enteritic Syndrome). This disease is continuing to cause problems in the warmer months on an increasing number of farms in the UK. In 2004 four sites in England were affected and five sites in Scotland. These sites are all table production sites and represent a significant proportion of the UK table trout production. Initial treatment methods using salt in the diet are still continuing to prove effective but in Europe, especially Spain where this disease is having a major economic impact, the effectiveness of a salt enriched diet is greatly reduced.

Strawberry disease/Red Mark Syndrome. In 2004, strawberry disease again showed itself at several fish farms in the south of England, and additional reliable reports were received of this condition on a number of sites in Scotland. Commercial small-scale field trials on farms have indicated that supplementary products in food (e.g. vitamin C) prior to the appearance of the condition can reduce its severity.

The aetiological agent has still not been identified and some confusion still remains over its diagnosis. A more recent condition known as ‘red mark syndrome’ has appeared, and persists through the colder temperatures of the winter months. It appears similar in many ways to strawberry disease and may only be differentiated by histo-pathology at certain stages. As the aetiological agent for this disease has not yet been identified it is possible that it may be the same or similar to that of strawberry disease. To complicate things further, the Fish Health Inspectorate has again received reports about triploids suffering a similar condition in fisheries. These fish have often exhausted all body fat reserves and may have suffered poor handling in catch and release fisheries.

Cyprinid Herpes Virus (CYHPII). In 2004, the Fish Health Inspectorate isolated and identified a herpes virus that appears to only affect varieties of goldfish

* *since this article was written BKD has been detected in two fish farms in England. Both fish farms are currently subject to Designated Area Orders.*

Carassius auratus. This is known as Cyprinid Herpes Virus (CYHP II). The disease seems to appear in the summer months after an increase of temperature from about 15ºC to 20ºC and leads to steady but low level losses. The main clinical symptoms at post mortem were necrotic crusty white gills, exophthalmia, pale skin with white pustules almost like blisters on the fins, enlarged spleens, kidneys and livers pale with small white nodules. Diagnosis was by PCR, cell culture and also by transmission electron microscope. One of the positive sites has been experiencing the problem for at least three years (PCR gave positive results on archive DNA material). Little is currently known as to the distribution of this disease. It is not clear yet if it is an emerging disease or if it is something that has been in the industry for some time and is widespread. A paper detailing the disease investigation will be published soon and further work is in progress.

Tench Rhabdovirus (TRV). In August 2004 following a chronic mortality in a recirculation system, Tench Rhabdovirus (TeRV) was isolated from fish submitted from the Environment Agency fish farm at Calverton. Further investigations across the whole site found antibodies to TeRV throughout all of the stocks and at the sister site at Leyland. Following these findings the Environment Agency took the decision to carry out a clearance and disinfection programme at both of the sites. Investigations into the cause of the outbreak are still continuing.

Koi Herpesvirus (KHV). In 2004 Koi Herpesvirus (KHV) continued as a cause of mortality in koi and other varieties of carp. In 2004 the number of investigations for KHV increased by 40% but the incidence of positive tests was significantly reduced, dropping to 11% of the samples. This probably reflects the ornamental industries move to only source stocks from sites with no history of KHV.

Investigations into mortalities on coarse fisheries provided further evidence for the spread of KHV into wild populations of common carp. Diagnostic tests implicated KHV in five disease investigations on coarse fisheries during the year, in each instance associated with significant mortalities.

One factor common to all herpesviruses is their ability to establish latency in their natural hosts and detection of these minute amounts of latent herpesviral DNA has proved impossible in fish with the current tools used for diagnosis (cell culture and PCR). This is most likely due to the amount of DNA or infectious virus being below the detection limits of both methods. However it is vital that populations of fish that have seen KHV before and may therefore be harbouring a latent infection be identified, to avoid the spread of the disease.

Studies into Koi Herpesvirus at the Cefas Weymouth Laboratory were designed and carried out with this very problem in mind, assessing potential exposure to KHV and therefore a possible latent KHV infection.

One possible method of determining exposed populations may be to test for antibodies to KHV. Laboratory challenges at Cefas provided populations of exposed fish and these exposed fish were then tested for antibodies and the data used to develop an antibody profile post exposure. One of the most common tools for measuring antibodies is an Enzyme Linked Immunosorbent Assay (ELISA) which requires a small (potentially non-lethal) sample of blood. The ELISA technique is rapid, relatively cheap and allows the diagnostician to screen many samples in one day. A KHV antibody ELISA developed at Weymouth was able to detect antibodies produced in individual fish, which confirmed exposure in the laboratory populations. The test appears reliable and consistent and is now being used in a national survey of farms and fisheries.

The ELISA is currently under development as a research tool, but such methods are not as yet considered appropriate diagnostic tools for legislation. However, such an antibody test may be the only method of determining exposure when carp exhibit no overt signs of disease, and may be the only way of accurately assessing latent infections of such an acute and devastating viral disease.

Defra sponsored R&D at Cefas Weymouth has been critical to the development of a reliable diagnostic PCR test for KHV. This PCR test can be performed on tissue samples from infected fish, and is a significant advancement in technique for the screening of fish and monitoring of the disease. Those seeking further information should contact the Cefas laboratory directly.

Import/export trade

The demand for licences to import fish from countries outside the EU, although continuing at a high level with a total of 430 licences issued, showed a decrease on the previous year. The largest decrease came in the applications for annual licences for tropical species, which fell by 50% in 2004. This probably reflects the industry trend to consolidate large orders to economize of costs and the accession of the Czech republic to the European Union. Table 2 gives details of the number and type of licences issued and also movement documents issued for fish exports, by fish type.

From May 2004 the new fish health certification requirements laid down in Commission Decision 2003/858 came into force. In order to provide sufficient time for importers and their export sources to familiarise themselves with the new fish health certification, transitional arrangements requiring importers of coldwater ornamental fish and other non-tropical fish to operate the new certification alongside

Table 2. Imports and exports of fish monitored by the Inspectorate in 2004

A.	**Import Licences by category for trade from Non-EU countries**		
	Tropical Species (Annual Licence)		94
	Koi & Goldfish (Annual Licence)		130
	Specified Purpose (Individual Licence)		157
	Human Consumption		49
		Total	430
B.	**Movement Documents for EU trade**		
	Import Documents Received/checked		
	Salmonid Eggs		74
	Turbot (for Direct Consumption)		144
	SVC Susceptible fish		69
	Other Fish		147
	Shellfish		20
		Total	454
C.	**Export documents issued**		
	Fish		63
	Shellfish		121
		Total	184

the exsiting licensing controls where instigated, ensuring the highest standards were maintained.

The major import trade remains that in tropical fish, goldfish and koi carp from outside the EU. Imports within the EU were predominantly salmonid eggs for farming and turbot for direct consumption with the imports of SVC susceptible fish down by 33%. This reduction reflects the loss of status of one of the approved farms in Italy following the isolation of SVC during a routine import check.

The export trade to the EU was down 75% on the previous year reflecting the change in status of England and Wales with respect to the Channel Islands, the Isle of Man and Ireland who took the majority of the SVC susceptible exports.

The Inspectorate maintained a high level of activity associated with the investigation of irregularities, and in particular in the prevention of illegal imports of live fish. Significant progress has been made in the development of a multi-Agency approach to the issue of illegal fish imports, and a clear improvement is evident in levels of co-operation between member states in combating this problem. The Inspectorate remains keen to receive any information about potentially illegal imports of fish and its HOTLINE number (01305 206681) is available 24 hours per day. The Inspectorate also operates an on-call system providing 24 hour cover by fish health inspectors. The duty inspector can be reached via the Defra duty office on 0207 2708960.

Summary

The Fish Health Inspectorate completed all of its statutory inspection programmes in 2004, and conducted all necessary investigations into reported fish disease outbreaks. The absence of any significant salmonid diseases supported the maintenance of approved zone status for VHS and IHN.

The isolation of SVC from imported fish and from coarse fishery waters reinforces the need to remain vigilant in our efforts towards the prevention of illegal fish imports and supports the need for the recently granted additional guarantees.

The Inspectorate is grateful for the co-operation shown by the fish farming industry, in the provision of samples, farm records and other information sought during site visits.

ANNOUNCEMENTS

URGENT PRESS RELEASE

BRITISH TROUT FARMING CONFERENCE 2005

It is with great regret that the Steering Committee of the British Trout Farming Conference announces the cancellation of the 2005 event, due to have been held at Sparsholt College, Hampshire on 7, 8 and 9 September 2005.

Over recent years, the Conference has struggled against limited input from the fish farming community and the Steering Committee, after consultation with members of the industry, has taken the difficult decision not to continue with plans for this September.

Hampshire has been home to a major, annual British fish farming conference for over 30 years. For the last 16 years, Sparsholt College has organised the British Trout Farming Conference, but for many years before this, nearby Two Lakes Fish Farm hosted a legendary fish farmers' gathering.

The Steering Committee is determined that the Conference will re-emerge in future years. Such an important discussion forum cannot be allowed to disappear. Therefore, plans are developing for a 2006 event; the Committee urges the fish farming world to commit to the future success of the Conference.

The British Trout Farming Steering Committee 2005:

Mark Burdass, Sparsholt College
Jane Davis, British Trout Association
Tim Ellis, Cefas
Robert Hughes, Skretting
Shaun Leonard, Sparsholt College
Nick Read, British Trout Association
Oliver Robinson, Test Valley Trout
Jimmy Turnbull, University of Stirling
Trevor Whyatt, Allenbrook Trout Farm.

FINFISH NEWS – THE NEW NAME FOR *TROUT NEWS*

It was announced in issue 37 (January 2004) that the remit of *Trout News* was expanding to reflect the diversification of the industry into production of finfish species other than salmonids. To reflect this remit change it has been decided to modify the name of *Trout News* to *Finfish News*, with effect from the next issue (January 2006). Articles relevant to the production of coarse and ornamental cold-water species and food fish in recirculation systems will be included in future editions in addition to those on salmonids. *Finfish News* will continue to provide an outlet for dissemination of research, policy and legislative information to the UK trout farming community as well as serving these new sectors. Contributions will be welcomed by the editors (contact details on inside front cover).

GUIDES TO PROTECTING FRESH WATER FISH PUBLISHED

Defra has published two further leaflets as part of its 'Keep Fish Disease Out' campaign. These follow the success of the gyrodactylosis leaflets launched last year.

These newly published leaflets are:

- 'A guide to protecting freshwater fish stocks from Gyrodactylosis and other serious fish diseases'

- 'A guide to protecting freshwater fish stocks from Spring Viraemia of Carp'.

The leaflets contain a description of the diseases, the species they affect and the action that fish farmers, fisheries managers and anglers should take to prevent the introduction or spread of freshwater fish disease in the UK.

None of the diseases outlined have implications for human health but they do have the potential to devastate the local ecological environment and cause serious financial damage to the fishing and angling industries.

Currently the UK has high standards of fish health but anyone suspicious of a possible outbreak of any notifiable fish disease should immediately contact the Fish Health Inspectorate at Cefas Weymouth.

The leaflets are being sent out to the industry and are also available on line http://www.efishbusiness.com/formsandguides/default.asp.

PRESS RELEASE
HUMANE KILLING OF SALMON AND TROUT

The Humane Slaughter Association (HSA) has announced the publication of its first booklet which focuses specifically on fish slaughter: Guidance Notes No. 5 – Humane Killing of Salmon and Trout. This unique booklet explains the principles of humane handling of fish immediately prior to and during slaughter. The transport of fish to slaughter in wellboats is also covered. It provides the reader with in-depth technical information in an easy-to-read format and will be a useful reference document for anybody involved in the handling and slaughter of fish within the aquaculture industry and veterinary profession. In addition to the description of humane methods, there is a chapter covering some of the more traditional methods which are no longer classed as humane and explanations are given as to why they are no longer recommended. The booklet has been written with the international market in mind and strong interest has already been shown by a number of countries outside of the UK. Copies are available from the HSA office at £5.00 each, or £3.50 for orders of ten copies or more. Commenting on the new publication, the HSA's Technical Officer, Tess Benson, said "This booklet is an invaluable reference document for anyone who may be involved with the humane killing of salmon and trout. Not only does it give clear and concise information about the various methods of slaughter, but also the implications that humane slaughter can have on the final product quality". For further information and details of how copies can be obtained contact The HSA Office on 01582 831919.

PRESS RELEASE
PROBIOTICS IN TROUT FEED CONFER PROTECTION AGAINST PATHOGEN AND HELP OPTIMISE FLESH QUALITY PARAMETERS

Promising results of a two-year collaboration programme between French research institutions and the industry were presented at Institut Pasteur, Paris

LALLEMAND ANIMAL NUTRITION
‘ animal sanum in natura sana ’

Lallemand Animal Nutrition have announced the completion of a two-year research programme on the benefits of probiotics in aquaculture. The programme is a joint collaboration between INRA, the French Agronomic Research Institute, Ifremer, the French Research Institute for the Exploitation of the Sea, and AFSSA, the French Agency for Food Safety and private companies (Lallemand, Viviers de France, Aquanord and Biomar). It was cofunded by OFIMER (French Interprofessional Syndicate of Sea Products and Aquaculture) and CIPA (Interprofesionnal Committee of Aquaculture Products), its objectives were to evaluate the impact of probiotics on the improvement of productivity, quality and safety in rainbow trout and seebass. Over 30 people, representing every level of the sector, (scientists from public Institutions, official authorities, independent veterinaries, feed producers, fish farmers, representative of the fish processing industry, professional syndicates, journalists), gathered at Institut Pasteur on 2nd March to hear the results of the study. The event, placed under the auspices of Louis Pasteur, the father of microbiology, was dedicated to the impact of probiotics in fish farming, and as such, was also designed as an opportunity for open discussions and debates between all the actors of the industry about the promises and realities of probiotics in aquaculture. The results that were presented show the benefits of probiotics in aquaculture, particularly in terms of flesh quality and sanitary problems prevention.

Commenting on the conference, Bruno Rochet, President of the European Probiotics Association, said: “The programme presented today is the result of a close collaboration between research and industry and we’ve shown today that this kind of initiative is extremely positive and can benefit each actor of the sector. I take this opportunity to thank all the partners involved in the study as well as OFIMER and CIPA, which funded the project. The results presented today are very promising and, while not sufficient to draw definitive conclusions on the use of probiotics in aquaculture, they encourage us to pursue in this direction. I can tell you today that further studies are already on their way.”

The programme presented involved studies in both experimental and production conditions, for rainbow trout, the main freshwater fish produced in Europe, and for seabass. Two types of probiotics were tested: live yeast *Saccharomyces boulardii* (Levucell SB®) and a lactic acid producing bacteria, *Pediococcus acidilactici* (Bactocell®), either alone, or in combination.

The part of the study dedicated to the influence of probiotics on the immune response, and conducted by the team of Dr Claire Quentel at the AFSSA, gave very promising results. In experimental conditions, trouts challenged with *Yersinia ruckeri*, a common and recurring pathogen in the aquaculture industry, were extremely resistant to the infection after four months treatment with probiotics. Levucell SB gave the best protection, even when high doses of pathogens were used: 5-6% of the trout died in the Levucell SB group compared to a 80-90% mortality rate in the untreated group. Moreover, in the probiotic group, the rate of healthy carrier of *Yersinia* also decreased from 80% (control group) to 15% (Levucell group), demonstrating that probiotics act as a prophylactic agent. Bactocell also conferred significant protection against infection, with a 15-25% mortality rate.

When zootechnical parameters were studied, it came out that, in the case of trout, the lipid content was significantly enhanced in muscle due to probiotics, as well as coloration whenever it wasn’t optimal. Peri-visceral fat was unchanged, meaning that carcass grade was unaffected. The occurrence of vertebra compression was also reduced with both probiotics. These observations allowed J. Aubin from INRA, responsible for the programme, to conclude that: “Probiotics showed no negative impact on fish quality and productivity, and could enhance flesh quality parameters when these were not optimum. So far, we can conclude to a compensating action of probiotics.”

The interaction of the probiotics with the digestive tract and its endogenous microflora was also extensively studied. It was shown that both probiotics survive and transit well in the trout digestive tract and, in the case of Levucell SB, the probiotic is even shown to adhere to the mucosa and influence the microbial balance. In the case of growing seabass, Levucell SB didn't survive in the intestine of the fish, although the survival of Levucell SB has been already demonstrated in the gut of marine fish larvae. This may explain the lack of effect observed in seabass after metamorphosis. Dr Gatesoupe, from a joint team INRA-Ifremer, concluded on his part of the work: "The environmental variability and some parameters difficult to control such as water quality are inherent issues in aquaculture. We've shown in this study that fish intestinal microbiota is extremely variable in time and between breeding sites for a given species, and this is why I think that probiotics, with their ability to regulate microbiota and intestinal mucosa, may contribute to a healthy and controlled breeding, without any detrimental impact on the environment. However, it is essential to test such treatments in representative panels of fish farms, before recommending their practical application."

A summary of the OFIMER programme report and high-resolution photos of the conference are available upon request at: sroquefeuil-dedieu@lallemand.com

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DEFRA AQUACULTURE DISINFECTANT LISTING SCHEME

Information for Manufacturers and Users

June 2005, First update

Introduction

Use of safe, effective disinfectants is very important for the implementation of effective biosecurity in intensive aquaculture, as for other farming operations. Important uses include treatment of equipment (e.g. tanks, nets or transportation containers) and effluent, limiting disease spread both within and between sites. Disinfectants are also required for decontamination of premises where there have been outbreaks of notifiable diseases (e.g. Infectious Salmon Anaemia (ISA), Spring Viraemia of Carp (SVC) or Viral Haemorrhagic Septicaemia (VHS)).

Under provisions of the Animal Health Act 1981, Defra maintain a list of disinfectants that are approved for use in the control of notifiable diseases of terrestrial animals and birds. This system of approval does not extend to the pathogens of fish and shellfish.
Defra is developing a new scheme that will give disinfectant manufacturers the opportunity to prove that their products are effective against relevant aquaculture pathogens, as well terrestrial diseases. Products that satisfy Defra criteria will be placed on a list, which will be freely accessible to farmers and aquaculture health professionals, aiding them in the selection of effective products.

The scheme will have UK-wide relevance and is being developed in consultation with representatives from FRS Marine Laboratory, Aberdeen (an agency of the Scottish Executive Environment and Rural Affairs Department), and the Department of Agriculture and Rural Development, Northern Ireland (DARD). The agencies responsible for the testing of disinfectants within the terrestrial scheme have also been consulted.

Disinfectant Testing Standards

The objective of Defra-sponsored project FC1169 (Aquaculture Disinfectant Listing Scheme) is to develop aquaculture disinfectant listing standards, and we are currently undertaking the laboratory standards testing component of this work. The standards are being developed in consultation with relevant experts from across the UK and Norway. (The Norwegian Medicines Agency administers an aquaculture disinfectant approvals scheme under a draft of the Biocides Directive BPD 98/8/EC.)

Stakeholders Forum

There is a proposal to hold a meeting by the end of 2005 with a range of stakeholders – including industry representatives, aquaculture health professionals, other Competent Authorities (CA) and farmers – prior to the scheme's finalisation. The venue and date still need to be finalised, but this will be confirmed in due course.

Further information

Contact David Verner-Jeffreys at
Cefas, Weymouth Laboratory, Barrack Road,
The Nothe, Weymouth DT4 8UB.
E-mail d.verner-jeffreys@cefas.co.uk
Telephone: 01305 206725.

INFORMATION FILE

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 Cefas publications '*Trout News*' and '*Shellfish News*', which are sent free to all registered fish and shellfish farmers and placed on our web site www.efishbusiness.com. Additional copies of our Charter can be obtained from the FHI or on the Cefas web site www.cefas.co.uk.

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

An increasing number of callers are directed to our web site dedicated to the movement and keeping of fish (www.efishbusiness.com) to fulfil their requirements e.g. to obtain forms, students researching projects. The volume of enquiries received by email to Fish.Health.Inspectorate@cefas.co.uk has continued to increase against previous years and now accounts for 60% of the correspondence received.

The following report shows the performance achieved against our target of 100%, for the period 1st April 2004 to 31st March 2005.

	Achieved in 2004-05
CORRESPONDENCE	
The Inspectorate's target is to reply to all letters, e-mails, faxes and complaints, within 10 working days of receipt.	96.8%
IMPORT LICENCE APPLICATIONS	
The Inspectorate has undertaken to issue import licences within 10 working days of receipt.	99%
DEPOSIT LICENCE APPLICATIONS	
The FHI issue lobster and mollusc deposit licences. These are not currently covered by our Citizen's Charter Statement, but it is currently our aim to issue them within 10 working days.	100%
MOVEMENT DOCUMENT APPLICATIONS	
The Inspectorate has agreed to respond to all requests for movement documents, provided 5 working days notice is given.	100%

FISH AND SHELLFISH FARM REGISTRATIONS

Registration visits

The Inspectorate has undertaken to visit all potential farmers within 20 working days of receipt of their application.	30.8%

Registration administration

The Inspectorate aim to complete the administrative action within a further 10 days from the date of the visit.	74.2%

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.	-
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.	77.8%

OVERALL RESULTS

The overall compliance rate with our set targets.	88.7%

The total amount of correspondence, and other actions covered by our Charter, recorded by the Inspectorate was 2537. Our performance fully met or approached our targets in most areas. We will continue to strive to achieve all our standards in 2005/2006.

Areas where compliance was low included farm registration visits, which in practice are arranged for mutually convenient dates for the FHI and the farmer. We also aim to make these visits as cost effective as possible. Unfortunately due to long term staff shortages and training the administrative action relating to farm registration had to be treated as low priority this year and has resulted in a lower standard being achieved in this area than usual. However, staff are now in post and trained and this situation has been rectified. The reporting of test results is often delayed where Inspectors involved in the disease investigation are conducting other routine inspection duties when the results of the investigation become available. Other inspectors may not be able report results on behalf of their colleague, as they are often unaware of the full circumstances of that disease investigation. Ways to improve our performance in this area are being implemented and we hope this will improve.

Customer care helpline

The purpose of our work is to prevent the introduction and spread of fish 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.

BTA NEWS

Jane Davis, Chief Executive, British Trout Association

BTA Office has moved from London to Edinburgh, with new offices situated at the Rural Centre near Edinburgh Airport, a location that has proved easily accessible to all of the membership. This year the BTA office will not always be manned as our Chief Executive, Jane Davis, is working part of each week for SEERAD on a secondment that aims to streamline the legislative framework for Scottish Aquaculture and increase access to veterinary medicines. If you cannot make contact with the BTA office, please also contact Nick Read.

British Trout Association
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Edinburgh EH28 8NZ
Tel: 0131 472 4080 Fax: 0131 472 4083

Jane Davis
Mb: 07957 144 028 j.davis@britishtrout.co.uk

Nick Read
Tel: 01453 521 929 n.read@btinternet.co.uk

Danish Study Tour, Biomar, 8-10 November

A group of BTA members visited Denmark, hosted by BIOMAR, to see the advances in technology being made by the Danish trout industry in response to government moves that will reduce substantially the abstraction of water from rivers.

Various degrees of re-circulation aquaculture systems (RAS) were seen, with approaches ranging from very low investment levels to complete re-builds of farms designed to operate with low or nil abstraction from the rivers.

It was apparent that the developments were going to result in increased productivity in tonnes per man/year and some very low overall production costs were being quoted. There have been grants available to Danish farmers to make these investments. In UK we have not had access to FIFG grants in areas where most trout farms are sited but this is about to change. See separate piece on FIFG.

Financial Instrument for Fisheries Guidance (FIFG Grants)

The UK government has done well to secure access to FIFG grants for those in areas outside Objective 1 Zones, which BTA and others have requested for some time. There are slight differences according to whether you are based in England or in devolved Wales or Scotland but in general terms, improvements on farms could now attract grant support at 40% of the cost. FIFG funds will not last forever, so if you are planning investment on your farm, talk to Nick Read or to Jane Davis for further information.

BTFRA Conference 4/5 November 2004

Conferences held by BTFRA have long had a reputation for being excellent venues for the necessary interchange of information among trout farmers and this meeting held at Dunster in Somerset was no exception.

Superbly organised by Ben Hanson from nearby Roadwater Fishery and with a finale barbeque run by Charlie Smith-Maxwell, the first day consisted of a number of presentations covering current and future problems facing the restocking sector of the industry. Notable was the talk given by Peter Scott of Toller Beattie Solicitors from Barnstaple, entitled Protecting Water Quality for Fish Farming. The information given should be of use to all who are concerned with rights and responsibilities over water use. Printed or email copies of the talk are available from BTA office on request.

Fish Veterinary Society Conference, 23/24 November 2004

A two day conference at Edinburgh, centred around farmed fish welfare, was attended by around ninety people. It is intended to publish the proceedings which are likely to become a much used reference on the subject. The final afternoon was devoted to devising possible welfare indicators that could be useful in on-farm assessment of welfare.

Egg Fry and Fingerling, 20 January 2005

Held at the new BTA office location at The Rural Centre, Ingliston, this meeting brought together the bulk of the members working in the sector. A large part of the day was devoted to reviewing the work that has been going on in recent years of broodstock selection and considering how this could be taken forward with a wider range of participants.

It is fully accepted that the advent of gene technology offers the industry an opportunity to improve the stock with which it works in terms of disease resistance as well as the obvious goals of FCR and SGR. The advances made by the salmon industry over the last two decades owe much to their investment in this area. The difficulty has been one of involving broodstock holders of all scales rather that just the very largest operators. Coming out of the meeting was the clear intent to investigate structures operating in other industries that would hatcheries of different sizes to take part and also to reduce the risks implicit in investment in broodstock that could, potentially, be wiped out by disease problems.

R&D Steering Group, 25 January 2005

Again meeting at The Rural Centre, the small group involved reviewed the projects that BTA is presently supporting and agreed that there is urgent need for a new project to investigate and find a solution to Rainbow Trout Gastro-Entiritis (RTGE) which is becoming a serious cost to the industry in both Scotland and in England.

Gastro-enteritis (RTGE)

Has been spreading fast and is costing the industry large amounts of money. BTA is instigating a research project to be carried out at Institute of Aquaculture at Stirling. Grant funding support is being sought from Defra and SARF.

New Members

We are pleased to welcome two new members to BTA:

In Devon, Mark Gorick has purchased Wilmington Trout Farm and may be contacted on 01404 831 459, Fax 831 489. mlg@wtfarm.wanadoo.co.uk

In Scotland, Inverness Fish Farming run by Craig Ireland and Nick Mardall, can be contacted on 01540 651 632, delfourhatchery@aol.com

On-farm mixing of medicated feed

The rules changed on 1 April and registration is now essential in order to be able to order medicines. The BTA has developed a Briefing Note, a Flow Chart and a HACCP Document to assist in meeting the requirements of the legislation.

There are cost implications in this change, the implementation of which has been delayed since 1998, when the new EU regulations were first introduced.

BTA and Peter Scott, have been in long running discussions with Veterinary Medicines Directorate (VMD) over how best to handle the matter and VMD have accommodated the position of the fish farming industry to a large extent. Any farms not registered and wishing to be so should contact BTA Office for assistance.

Market comment

Discussion at the Trout Commission of FEAP AGM in May revolved around the conundrum facing trout producers in most of the major producing countries in EU.

Trout are in generally short supply across Europe but this has achieved no improvement in price. The short supply is due, in large measure to trout farmers closing down because of the low ex-farm prices being achieved.

There was a widely held belief that this situation reflected the dominant role of major retailers in the market and the strong competition between them. Looking forward, the availability of trout supplies in UK cannot be expected to improve this year. Low rainfall through last winter is likely to add to the problems.

A Farmers Guide to the Production of All-female Triploid Brown Trout

A farmer's guide produced in conjunction with the Environment Agency and validated by Cefas is now available free to members of the BTA. The intellectual property contained in this guide means that its circulation is restricted. Non BTA members who would like a copy of the guide are requested to contact the BTA office for further information.

White Spot Research Development

The BTA/Defra/SARF sponsored research project into the management and control of white spot has just now come to an end. An article of the work is included in this issue of *Trout News*. A novel white spot cyst vacuuming device has also been developed.

Diffuse pollution

Over the years, trout farms, with their defined discharges, have been a relatively visible and simple target in efforts to improve river quality. It is encouraging that government, through The Environment Agency and SEPA, are now concentrating on widespread and diffuse pollution from agriculture. There is little doubt that considerable improvements can be made over time, but that it will involve much detailed work by a large number of farmers. An early move is the holding, by EA, of a number of Soil Workshops at strategic points around the country. In the long term, all this will benefit trout farmers with improved quality of supply water.

Mail Order

Any farms involved in mail order of trout products may be interested to know that Food Standards Agency has, in preparation, an Industry Guide to Good Hygiene Practice: Mail Order /Distance Selling of Foods.

A number of similar guides to the same format have already been developed for other parts of the food industry and the whole process is most detailed and time consuming. The Mail Order Industry Guide will not be available until early in 2006 but will then provide clear directions to officials such as Environmental Health Officers on what they should expect from businesses involved in Mail Order. BTA has a seat on the working group that is contributing to the content of the guide.

Mort disposal, ABPR, National Fallen Stock Company

The Animal By-Products Regulation came into force in 2003 and made illegal most of the methods hitherto employed for the disposal of fish farm morts. As has been reported in several previous Newsletters, enforcement has been low key since the introduction of the Regulation due to a lack of disposal routes that could comply with the Regulation.

Meanwhile, government funded research work has been carried out at Cefas and at FRS, Aberdeen, to establish methods to make morts bio-secure. That work is now completed and should result in an approved method of ensiling the morts using alkali, rather than acid which does not eliminate IPN Virus. Ensiling is only a method of storage but it will allow morts to be safely held on site until an economic quantity can be disposed of.

It is intended that the research will result in an alternative disposal route for morts, once a protocol has been approved by Brussels and the legislative barriers connected with waste disposal have been overcome within UK.

Barramundi to be grown in UK

It is being reported that a Barramundi production unit is being built in the New Forest using Recirculation Aquaculture and that another unit is also being planned.

Phages

Working with a very limited range of treatments for the disease challenges on our farms, an announcement from Australia may point towards a future area that might tilt the battle for improved fish health in our favour.

A company, in New South Wales, Special Phage Services, has been awarded a grant of around £100K by The Federal Government Biotechnology Innovation Fund to research the use of phages, initially to overcome the problem of bacteria outbreaks in the aquaculture industry. Phages are viruses which predate on bacteria and have been successfully used in the former Soviet Union for more than seventy years. In the west their use was superseded by the introduction of antibiotics. More info from: http://www.biotechnologydirectory.com.au/companies/sps.htm*.

CARD R&D UPDATE – WHAT DOES THE FUTURE HOLD?

Dr Mark James, FRM Ltd – Co-ordinating Defra CARD funding

There is positive progress to report in a number of areas related to aquaculture R&D and work on trout in particular. Despite a general lack of significant strategic investment in R&D in this sector in recent years, the structures that guide what limited resources are available have continued to deliver a focused portfolio of projects providing a flow of practical outcomes of benefit to the industry.

Through the Committee for Aquaculture Research and Development (CARD), Defra has provided support for 18 projects through an allocation of approximately £1million between 2003 and 2008. The allocation of the funds remaining from this commitment will take place in the near future, to projects related to rainbow trout gastro-enteritis and a strategic assessment of the scale, structure and segmentation of the ornamental industry in the UK.

The average cost of research projects has doubled in the past ten years and the amount of money available has either remained the same or, more recently, declined. As a result, fewer substantive projects have been commissioned with the majority of applied R&D funding being spread over a number of small, relatively short-term projects. Although not an ideal scenario in terms of securing the UK's technological advantage, many of these projects have delivered important advances. As the Defra CARD funding comes to an end, there seems little prospect at this stage, of future funding through this mechanism. However, the Scottish Aquaculture Research Forum (SARF) is now well established and

** Defra is also sponsoring research in this interesting area - Project FC1156 (Investigations into the potential of phage therapy for the control and prevention of fish disease). More information can be found on the Defra website at www.defra.gov.uk/research/project_data/Default.asp.*

is in the process of commissioning research prioritised by its Board of Directors – a Board drawn from a wide range of aquaculture stakeholder groups in Scotland. As a Company and registered Charity, SARF draws its funding from a range of public and private Member organisations. Through its Inshore and Aquaculture Group, Seafish is also contributing funds to R&D, with the focus very much on applied near market work.

Securing R&D funding now, more than ever, requires collaboration between sponsors – some of whom have little or no background in aquaculture, but may have a remit to sponsor related R&D. This situation demands good communications, openness, and above all trust founded in confidence that well managed commissioned research will deliver results and represents good value for money.

One of the consistent themes emerging through R&D prioritisation exercises has been the need to expand the range of disease treatments available to the aquaculture industry. In response, Defra, together with a number of public and private co-sponsors has commissioned a raft of projects designed to address this issue.

In order to identify potentially new treatments for fungal diseases in salmonids, Defra and Scottish Quality Salmon have co-sponsored two projects (Defra Projects FC0928 and FC1162). The first was to conduct an international search for products or compounds that have suitable existing registrations (e.g. for agrochemical use) that might be suitable for the treatment of fungal disease in salmonids. The contractors, Triveritas, successfully identified 10 candidate compounds which are now being tested as part of a second project involving Triveritas and Cefas Weymouth. Due to finish in October 2006, this project is progressing well and there is a good prospect that some of the compounds being tested will eventually find their way onto the fish farm.

Ichthyophthirius multifiliis or whitespot disease is one of the most pathogenic diseases of cultured fish in freshwater and is a major problem for the UK trout industry. With the withdrawal of malachite green, there is no acceptable means for its treatment. An earlier LINK aquaculture project (TRT06) carried out by the University of Stirling, however, identified a number of potential in-feed chemotherapeutants. The main objective of a follow-on Defra-CARD project (Defra Project FC1158) at Stirling was to trial these compounds in the field and to build their use into a strategy for the control of the parasite in trout farms. The results of this project were augmented by long-term records of fish health monitoring provided by one of the British Trout Association (BTA) farms involved in the study. The project finished earlier this year and has provided important insights into the potential management of *I.multifiliis*, using a targeted combination of chemotherapeutants and nutraceuticals. Defra, SARF and the BTA are now co-sponsoring what we hope will be the final phase of this work (Defra Project FC1164) which is testing the efficacy of three novel approaches (developed in the previous project) to control and treat outbreaks of *I. multifiliis* in rainbow trout farms. This project is due to be completed by July 2005.

Proliferative Kidney Disease (PKD) has long been a major economic constraint on the rainbow trout industry. It is caused by a Myxozoan parasite *T. bryosalmonae*. Defra, the BTA and others are currently funding a two-pronged approach to combating this disease – genetic selection for resistance and vaccine development.

Selective breeding using modern molecular genetics techniques and the latest quantitative genetic models has been used to assess the potential for setting up a broodstock selection programme for the trout industry in the UK. Work originating from a LINK project (TRT12) based at the University of Stirling which identified significant potential for genetic improvement in the trout stocks analysed, also generated experimental material which could be used to look at the possibility of genetic resistance to PKD. Together with the BTA, Defra is currently sponsoring a PhD studentship to further investigate this potential (Defra Project FC0929).

Recent research has identified antigens that may be important in conferring immunity to fish. Defra, the BTA and Schering-Plough are sponsoring a three-year project (Defra Project FC1160) at the University of Stirling (ending November 2007), which aims to express these antigens and examine them in a series of vaccination trials with a view to developing a potential vaccine for PKD. Although only six months since starting, this project has made significant progress towards sequencing the gene encoding the B4 antigen which may be responsible for conferring immunity to the disease.

Rainbow Trout Fry Syndrome (RTFS), caused by *Flavobacterium psychrophilum,* continues to be one of the most significant diseases affecting the rainbow trout fry and fingerling industry in the UK. Antibiotic treatment of infected fish is currently the only method of control as no commercial vaccine is available to prevent the disease. This three year Defra (Project FC1161), BTA, Schering-Plough funded project (ending November 2007) will use a natural field challenge to test vaccine formulations comprising representative antigens from all serotypes (whole cell and specific fractions), while at the same time developing a standardised challenge model that will be required for batch efficacy testing of commercial vaccines. In addition, broodstock vaccination will be evaluated as a means of controlling RTFS. A novel approach is proposed to protect fish and eggs against infection by *Flavobacterium pshychrophilum* by administering anti-*F. phychrophilum* monoclonal antibodies (mAbs) in feed to fry (passive immunisation), and using anti-

F. phychrophilum mAbs to sterilise eggs. This project has made good initial progress towards determining the number of serotypes of *F. pshychrophilum* and in developing a standard disease challenge.

Anyone who has listened to Mr William Crowe of FEAP's animated accounts of EU debates on proposed animal welfare legislation will understand the need to establish sound scientific evidence to support the development of fish welfare related regulation. Defra and the BTA have supported a number of projects (Defra Projects FC0916, AW1203, AW1204 and AW1205) designed to improve our understanding of trout welfare – ranging from the development of a method for automated humane slaughter to novel techniques for non-invasively measuring the levels of cortisol, the classic stress hormone, produced by fish and released into water. Cefas have successfully developed this technique, and in collaboration with the University of Stirling have coupled it with more traditional methods such as condition indices, growth rate, and fin damage, to allow quantifiable measures of stress and performance to be directly related to stocking densities.

The size and scale of the ornamental fish industry in the UK is still largely undefined – all we can say with a reasonable degree of certainty is that it is a multimillion pound industry, involving around 2000 species and engaging a large number of people throughout the UK. In common with other areas of "mainstream" food production aquaculture, the greatest risk to the ornamental sector is disease – diseases causing mortality to saleable stock and, in addition, the threat of disease transfer to native species through importation. Through CARD, and in response to the concerns of the UK ornamental industry, Defra sponsored an International workshop on koi Herpesvirus (KHV) (see Defra website at www.defra.gov.uk/research/project_data/Default.asp for further information). The purpose of the workshop was to raise general awareness amongst regulators, scientists and the industry of the current status of KHV with respect to its management, identification and potential treatment. The workshop clearly stimulated research activity in a number of countries and helped to improve communications between members of the scientific community with divergent views. As a result, Defra has been able to define the areas of R&D it should be supporting in a global context and focusing UK research effort on the development of diagnostic tools – through a co-funded project with the Ornamental and Aquatic Trade Association, based at Cefas which is currently optimising and standardising Polymerase Chain Reaction (PCR) assay protocols for KHV (Defra Project FC1163).

This one year, low budget project epitomises the highly focused and industry-policy oriented nature of the projects that have been supported through Defra-CARD funds. Similarly prioritised work has been funded on shellfish related areas, such as identification of sources of faecal sewage contamination and the effects of effemoral seed mussel collection. The thorny issue of fish meal sustainability has long been the subject of debate – a debate reinvigorated by the prospect of growth in the cod production. Cod and other marine species require feeds with a relatively high protein content. To explore the potential for fish meal substition with plant proteins, Defra sponored two short term projects at SAMS Ardtoe to test the growth performance and potential welfare implications of using full fat soya as a fish meal substitute (Defra Projects FC0931 and FC0932). The results clearly demonstrated that a significant proportion of the diet could be replaced by full fat soya with only marginal impact on fish performance. The involvement of a number of feed manufacturers in this project together with a positive price differential in favour of using full fat soya (and some other plant proteins) suggests that a range of replacement cod diets could soon be available.

But what of the future? If the aquaculture sector is to survive and expand sustainably in all parts of the UK, there is a need to develop and maintain a dynamic and strategic vision of potential opportunities and threats. Continued expansion in the domestic consumption of fish and seafood generally, will mean that these products will inceasingly be sourced from aquaculture – indeed the Food and Agriculture Organisation predicts that by 2020, aquaculture will (on a global scale) be the prime source of seafood. With food safety and traceability being paramount in food production, together with consistency and continuity of supply, there is a certain inevitablity that aquaculture will gain in importance. As energy costs are likely to increase significantly in the next few decades, coupled with the need to reduce green-house gas emissions and conserve resources, there will be pressure to optimise food production efficiency – particularly high value proteins and oils such as omega 3's. Minimising "food miles" in terms of product sourcing is an issue that is rapidly gaining momentum – further increasing the pressure to produce and procure food locally.

Domestication of aquacutured species through genetic selection is still at a relatively early stage, but shows great promise in terms of improved disease resistance and growth performance. For offshore and land-based recirculation aquaculture to develop, production costs will need to be further reduced – better disease control, coupled with improved survival and growth performance will help to drive these developments forward.

The development of non-food products from aquaculture is an emerging area of science that will undoubtedly come of age in the near future and be recognised as a fundamental part of developing and cultivating marine and freshwater resources sustainably. Over the next decade, land based agriculture is set to change signficantly with rationalisation of EU subsidies, leading to a massive increase in the production of industrial crops for use as biofuels, as well as sources of raw materials for the chemical, pharmaceutical and engineering industries. Aquaculturists will need to keep abreast of these changes, and scientists and political institutions will need to ensure that we are prepared for them.

WHERE TO GET HELP AND ADVICE

Policy Matters

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

Fish farming policy:-
Fisheries Division II, Area 5E, 8-10 Whitehall Place,
London, SW1A 2HH
(Tel. 020 7270 8826) (Fax. 020 7270 8827)

Grant Aid:-
Fisheries Division 1B, Area 6D, 3-8 Whitehall Place
London, SW1A 2HH
(Tel. 020 7270 8041) (Fax. 020 7270 8019)

Research and Development Programmes:-
Fisheries Science Unit, Area 6C, 3-8 Whitehall Place,
London, SW1A 2HH
(Tel. 020 7270 8274) (Fax. 020 7270 8020)

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

The Welsh Assembly Government, Agriculture and
Rural Affairs Department,
Agricultural Policy Division 5,
New Crown Buildings, Cathays Park, Cardiff CF1 3NQ
(Tel. 02920 823567) (Fax. 02920 823562)
www.wales.gov.uk

Scottish Executive Environment and 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 for
Northern Ireland,
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,
The Rural Centre, West Mains, Inglistone
Mid-Lothian, EH28 8NZ
(Tel. 0131 472 4080)
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)
www.snh.org.uk

Other Useful Numbers

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RESEARCH NEWS

1. RTFS transmission study

The bacterium *Flavobacterium psychrophilum* causes RTFS in rainbow trout. In this study the occurrence of *F. psychrophilum* at four rainbow trout hatcheries was investigated to provide more knowledge about the reservoirs and transmission of this bacterium. Broodstock were sampled at stripping (including both unfertilised and fertilized eggs), and the offspring were then sampled at the eyed egg and fry stages. Water and surface samples (e.g. hatchery trays) were also sampled. *F. psychrophilum* was found in ovarian fluid and milt, indicating that broodstock may serve as a reservoir and are latent carriers of the pathogen. *F. psychrophilum* was not found on or inside eggs, but further egg studies will be necessary to elucidate the possibility of vertical transmission of the pathogen. *F. psychrophilum* was isolated from water samples, but only from water that had been in close contact with farmed rainbow trout or eggs. The same strain was found in broodstock, in water samples from hatchery trays and in fry, which suggests the possibility of transmission of *F. psychrophilum* between broodstock and offspring.

Madsen, L. (Danish Inst Fisheries Res, Fish Dis Lab, Stigbojlen 4, DK-1870 Frederiksberg C, Denmark. Email: lm@dfu.min.dk), Moller, J.D. and Dalsgaard, I. (2005). *Flavobacterium psychrophilum* in rainbow trout, *Oncorhynchus mykiss* (Walbaum), hatcheries: studies on broodstock, eggs, fry and environment. *Journal of Fish Diseases*, 28: 39-47.

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2. Lactococcosis in Portuguese trout

This report provides the first description of epizootic episodes of Lactococcosis in North Portugal which caused important mortalities in cultured rainbow trout. The outbreaks were associated with high water temperatures during the warm seasons of 2002 and 2003 and affected all sizes of fish, reaching up to 90% mortality on some farms. Studies of the isolates obtained demonstrated them to be highly pathogenic for rainbow trout and that they were *Lactococcus garvieae*. Lactococcosis caused by *L. garvieae* is therefore an emerging disease for the Portuguese trout industry and appropriate measures must be taken in order to avoid its spread to other areas.

Pereira, R. (CIIMAR, Lab San, Rua Bragas 177, P-4150123 Oporto, Portugal), Ravelo, C., Toranzo, A.E. and Romalde, J.L. (2004). *Lactococcus garvieae*, an emerging pathogen for the Portuguese trout culture. *Bulletin of the European Association of Fish Pathologists*, 24: 274-279.

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3. Rearing conditions affect infection

The influence of rearing density and water temperature on *Flavobacterium columnare* infection, the causative agent of columnaris disease of rainbow trout, were studied experimentally. Mortality was higher in fish at normal rearing density at high temperature (23°C). At lower temperature (18°C) mortality was not affected by rearing density, but the transmission of the disease was faster at normal rearing density than lower densities at both temperatures. This supports the view that reduction of fish density could be used in prevention of columnaris disease especially if water temperature is high. Because a lower rearing density can also decrease the transmission of ectoparasites and penetrating endoparasites, it could be an efficient tool in ecological disease management.

Suomalainen, L.R. (Univ Jyvaskyla, Dept Biol & Environm Sci, POB 35, FIN-40014 Jyvaskyla, Finland. Email: lottari@bytl.jyu.fi), Tiirola, M.A. and Valtonen, E.T. (2005). Influence of rearing conditions on *Flavobacterium columnare* infection of rainbow trout, *Oncorhynchus mykiss* (Walbaum). *Journal of Fish Diseases*, 28: 271-277.

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4. Size and age affect resistance to whirling disease

This study examined the effects of both fish age and size on the development of resistance to whirling disease in rainbow trout. It had previously been demonstrated that juvenile rainbow trout became resistant to development of the disease when first exposed to the parasite *Myxobolus cerebralis* at about 9 wk post-hatch when raised at 12°C. In this study, rainbow trout of the same age but different sizes, and the same size but different ages, were exposed to the parasite to distinguish the influences of age and size. Fish were reared at 3 different water temperatures to produce groups with different growth rates and were exposed to the parasite at 7 or 9 wk post-hatch. Disease severity was affected by both age and size at first exposure, but the effects were not independent. An increase in length from 36 to 40 mm among fish exposed at 7 wk post-hatch did not confer increased resistance, but the same increase in size at 9 wk post-hatch did. Similarly, an increase in age from 7 to 9 wk post-hatch among fish exposed at 36 mm length did not confer increased resistance, but the same increase in age at 40 mm did. It was concluded that rainbow trout must be both 9 wk post-hatch or older and at least 40 mm in fork length at time of exposure to exhibit enhanced resistance to whirling disease.

Ryce, E.K.N. (Montana State Univ, Dept Ecol US Geol Survey Montana Cooperat Fishery Res Unit, Bozeman, MT 59717, USA. Email: eryce@state.mt.us), Zale, A.V., MacConnell, E. and Nelson, M. (2005). Effects of fish age versus size on the development of whirling disease in rainbow trout. *Diseases of Aquatic Organisms*, 63: 69-76.

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5. Risk assessment for *G. salaris* introduction

Gyrodactylus salaris is a freshwater, monogenean ectoparasite of Baltic strains of Atlantic salmon on which it generally causes no clinical disease. Infection of other strains of Atlantic salmon in Norway has resulted in high levels of juvenile salmon mortality and significant reductions in the population. The parasite is a major exotic disease threat to wild Atlantic salmon in the UK. This paper qualitatively assesses the risk of introduction and establishment of *G. salaris* into the UK. The current UK fish health regime prevents the importation of live salmonids from freshwater in territories that have not substantiated freedom from *G. salaris*. The importation of other species, e.g. eels *Anguilla anguilla* and non-salmonid fish, represents a low risk because the likelihood of infection is very low and the parasite can only survive on these hosts for less than 50 d. Importation of salmon carcasses presents a negligible risk because harvested fish originate from seawater sites and the parasite cannot survive full strength salinity. The importation of rainbow trout *Oncorhynchus mykiss* carcasses from *G. salaris* infected freshwater sites might introduce the parasite, but establishment is only likely if carcasses are processed on a salmonid farm in the UK. A number of mechanical transmission routes were considered (e.g. angling equipment, canoes, ballast water) and the most important was judged to be the movement of live fish transporters from farms on mainland Europe direct to UK fish farms. In the future, territories may have to substantiate freedom from *G. salaris* and economic drivers for live salmonid imports may strengthen. Under these circumstances, legal or illegal live salmonid imports would become the most significant risk of introduction.

Peeler, E.J. (Ctr Environm Fisheries & Aquaculture Sci, Barrack Rd, Weymouth DT4 8UB, England. Email: e.j.peeler@cefas.co.uk) and Thrush, M.A. (2004). Qualitative analysis of the risk of introducing *Gyrodactylus salaris* into the United Kingdom. *Diseases of Aquatic Organisms*, 62: 103-113.

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6. The Norwegian action plan against salmon lice

Norway is home to the largest populations of Atlantic salmon, and has the largest salmon-farming industry in the world. Salmon lice emerged as a problem soon after establishment of the industry in the 1970s. This parasitic copepod has been blamed for the collapse of sea trout stocks in several countries, and is also perceived as a serious threat to wild Atlantic salmon smolts migrating through Norwegian fjords and coastal areas in spring. The National Action Plan Against Salmon Lice on Salmonids (NA) was implemented in 1997 in Norway. This Action Plan was drawn up by the Animal Health Authority (AHA), fish health personnel and fish farmers, and was a consensus tool to reduce the impact of lice from farmed fish. Important measures in the NA were legal limits for the maximum mean number of lice per farmed fish, compulsory reporting of lice numbers to the AHA, strategic regional treatments against lice, and monitoring of salmon lice infection in wild salmonids. In this review the implementation of the NA is examined, and the success of the actions taken is evaluated in terms of the lice loads found on wild salmonids in 1998-2002.

Heuch, P.A. (Natl Vet Inst, Sect Fish Hlth, POB 8156 DEP, N-0033 Oslo, Norway. Email: peter-andreas.heuch@vetinst.no), Bjorn, P.A., Finstad, B., Holst, J.C., Asplin, L. and Nilsen, F. (2005). A review of the Norwegian 'National Action Plan Against Salmon Lice on Salmonids': The effect on wild salmonids. *Aquaculture*, 246: 79-92.

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7. North American biosecurity survey

This paper provides the first empirical characterization of biosecurity utilization in finfish aquaculture. A questionnaire survey was mailed to managers of finfish-rearing recirculation facilities in the United States and Canada to obtain baseline data on the frequency of use of 11 different biosecurity measures. The response rate to the survey was 86%. Of the 139 respondents, 71% were from the United States (n = 93) and 29% were from Canada (n = 38). The data show that biosecurity utilization is not homogenous within the finfish recirculation sector of the United States and Canada. Overall, inexpensive and low-tech biosecurity practices were utilized the most. The most frequently practiced measures were record-keeping (94%) and dead fish collection (93%). Present use of vaccines (17%) was less than past use (30%). 66% of facilities reported prophylactic use of chemicals while 81% reported therapeutic use (chemical treatments included the use of salt). Quarantine procedures on incoming fish and/or eggs were commonly employed in recirculation facilities, with use of an isolation area occurring more frequently (83%) than use of an isolated water supply (66%). 75% of surveyed facilities had employed the services of a fish health specialist with the majority of facilities using a specialist in the previous 8 months. Biosecurity practices were found to be related to primary water source, type of fish grown, purpose of the operation and country of operation. Within the recirculation sector: biosecurity utilization was most prevalent at facilities growing Atlantic salmon. The number of years of work experience the manager had in aquaculture was found to be significantly associated with present vaccine use, past vaccine use and use of fish health specialists. The study lays the foundation for further research on biosecurity utilization in aquaculture and provides insight into factors that influence frequency of use of biosecurity.

DALABBIO, J. (Bluefield State Coll, Dept Aquaculture, Bluefield, WV 24701, USA. Email: jdelabbi@hotmail.com), MURPHY, B.R., JOHNSON, G.R. AND MCMULLIN, S.L. (2004). An assessment of biosecurity utilization in the recirculation sector of finfish aquaculture in the United States and Canada. *Aquaculture*, 242: 165-179.

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8. GM salmon review

Over the past 20 years stable lines of transgenic Atlantic salmon have been generated possessing either antifreeze protein (AFP) genes or a salmon growth hormone (GH) gene construct. The AFP gene transfer studies started in 1982. The AFP transgene integrated into salmon genomic DNA and AFP has been found in the blood of all 5 generations to date. However, AFP levels are low and a means to raise these levels needs to be developed. GH gene transfer studies started in 1989. Evidence to date indicates that a single copy of the GH transgene integrated into chromosomal DNA and has been passed down in Mendelian fashion, along with its rapid growth phenotype, over 6 generations. Laboratory studies indicate that the GH transgene enhances growth rates with Atlantic salmon reaching market size (4 - 6 kg) a year earlier than non-transgenics cultured commercially in Atlantic Canada. This GH gene transfer technology was patented and licensed to Aqua Bounty Farms Inc., and the transgenic salmon are currently under review by various government regulatory authorities in the USA and Canada for use in commercial aquaculture ventures. Our experience with the regulatory authorities, the industry and the press indicates that the successful introduction of transgenic salmon into the aquaculture industry involves issues concerning not only science but also food safety, environmental safety, animal welfare and consumer acceptance. This communication reviews experience with Atlantic salmon and outlines plans and progress towards demonstrating the safety of transgenic fish to the consumer and to the environment.

FLETCHER, G.L. (Mem Univ Newfoundland, Ctr Ocean Sci, St Johns, NF A1C 5S7, Canada. Email: gfletcher@aquabounty.com), SHEARS, M.A., YASKOWIAK, E. S., KING, M.J. AND GODDARD, S.V. (2004). Gene transfer: potential to enhance the genome of Atlantic salmon for aquaculture. *Australian Journal of Experimental Agriculture*, 44: 1095-1100.

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9. Contaminant reduction by feeding vegetable oil

In this study groups of Atlantic salmon were fed one of four diets from first feeding to harvest after 115 weeks and contaminant levels were measured. The four diets were low fish oil (17% w/w, LFO), high fish oil (35% w/w, HFO), low vegetable oil (17%, linseed /rapeseed oil , 1:1 w/w; LVO) and high vegetable oil (35%, HVO). The dioxin concentration in diets was in order HVO< LVO< LFO<HFO, with values ranging from 0.16 to 1.4 ng TEQ/kg. The dioxin-like polychlorinated biphenyl (DL-PCB) concentrations were in the same order with values ranging from 0.62 to 3.68 ng TEQ/kg. Flesh samples were taken from fish at 2.1 kg. Concentrations of dioxins and DL-PCBs in flesh were correlated with feed concentrations, but values in flesh were always lower than in feed. Feeding the HVO diet reduced flesh concentrations of 20:5 n-3 (EPA) and 22:6 n-3 (DHA) to 25% of the values in fish fed the HFO diet. All groups were then switched to the HFO diet for a further 24 weeks as a finishing diet, after which the flesh dioxin concentrations ranged from 0.20 to 0.54 ng TEQ/kg and the DL-PCBs from 0.66 to 1.07 ng TEQ/kg. Feeding the finishing diet did increase dioxin levels in the flesh of fish previously fed the LFO, LVO and HVO diets, although values were still significantly lower than in fish fed the HFO diet throughout. However, feeding the HFO finishing diet for 24 weeks resulted in restoration of flesh EPA and DHA concentrations to 80% of the values in fish fed the HFO diet throughout. This study suggests that salmon fed fish meal and oil (HFO) diets attain flesh dioxin concentrations that are <14% of the current European Commission limit. However, by replacing marine fish oils with vegetable oils for most of the production cycle, dioxin and DL-PCB concentrations can be substantially reduced.

BELL, J.G. (Univ Stirling, Inst Aquaculture, Stirling FK9 4LA, Scotland. Email: g.j.bell@stir.ac.uk), MCGHEE, F., DICK, J.R. AND TOCHER, D.R. (2005). Dioxin and dioxin-like polychlorinated biphenyls (PCBS) in Scottish farmed salmon (*Salmo salar*): effects of replacement of dietary marine fish oil vegetable oils. *Aquaculture*, 243: 305-314.

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10. Nutritional benefits of carotenoids

Carotenoids are responsible for the colour of a great number of both vegetable and animal foods, such as carrots, orange juice, tomato, salmon and egg yolk. It has been known for many years that some of these compounds, such as alpha and beta-carotene, as well as beta-cryptoxanthin, are provitamins A. However, recent studies have shown the antioxidant properties of these compounds and their efficiency in the prevention of certain human diseases, such as atherosclerosis and cancer. Interest in the nutritional benefits of these compounds has therefore increased substantially.

Melendez-Martinez, A.J. (Univ Sevilla, Fac Farm Area Nutr & Bromatol, E-41012 Seville, Spain), Vicario, I.M. and Heredia, F.J. (2004). Nutritional importance of carotenoid pigments. *Archivos Latinoamericanos De Nutricion*, 54: 149-154.

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11. Dietary Vitamin B6 increases DHA flesh content

Fish fillet quality is clearly influenced by feed quality. The availability of vitamin B-6 in the feed is thought to affect growth rate and nutritional value, because it is related to protein and lipid metabolism. This study investigated the effect of increasing amounts of dietary vitamin B-6 on growth and fatty acid composition of muscle tissue of rainbow trout . Groups of trout were fed commercial diets supplemented with four different quantities of vitamin B-6 (0, 10, 25 and 50 mg/kg diet). Over the experimental period, there were no significant differences in weight gain and feed intake. Vitamin B-6 concentration of muscle was affected by dietary intake, although its increase was not proportional to concentrations in the feed. The fatty acid composition of muscle lipid showed differences between the four groups. The percentage of long-chain unsaturated fatty acids, in particular DHA, increased significantly in vitamin B-6-supplemented groups.

Maranesi, M. (Univ Bologna, Dept Biochem G Moruzzi, Via Irnerio 48, I-40126 Bologna, Italy. Email: magda.maranesi@unibo.it), Marchetti, M., Bachicchio, D. and Cabrini, L. (2005). Vitamin B-6 supplementation increases the docosahexaenoic acid concentration of muscle lipids of rainbow trout (*Oncorhynchus mykiss*). *Aquaculture Research*, 36: 431-438.

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12. Welfare and flesh quality at slaughter

A reliable assessment of animal welfare at slaughter and its impact on product quality requires a multidisciplinary approach that takes into account fish behaviour and the different biochemical and physiological processes involved. This might be done by the contemporary study of changes of indicators of brain function, endocrine responses, post mortem tissue biochemical processes and quality changes. This paper reviews some of the most used indices of stress at the time of slaughter, commercial slaughter methods and related stress effects on physical and biochemical parameters of fish quality. The set of the available data indicates that preslaughter and slaughter stressful practices could have an important effect on flesh quality in fish. A clear effect emerged mostly on the physical properties of flesh, because severe stress at slaughter time exhausted muscular energies, produced more lactic acid, reduced muscular pH, and increased the rate of rigor mortis onset. Preslaughter and slaughter practices therefore have significant negative effects on technological traits, flesh quality and keeping quality of fish. Asphyxia and electrically stunned fish were more stressed than spiked, knocked and live chilled fish. Combining various methods together might be a more satisfactory strategy for both animal welfare and product quality.

Poli, B.M. (Univ Florence, Dept Sci Zootecn, Via Cascine 5, I-50144 Florence, Italy. Email: biancamaria.poli@unif.it), Parisi, G., Scappini, F. and Zampacavallo, G. (2005). Fish welfare and quality as affected by pre-slaughter and slaughter management. *Aquaculture International*, 13: 29-49.

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13. Review of sustainability in aquaculture

Sustainable and long-term growth of the aquaculture industry should involve both ecologically sound practices and appropriate resource management. Aquaculture may provide a valid support to reduce the pressures on traditional fisheries. Aquaculture practices can also lead to modifications of habitats through the impact of wastes. In addition to these aspects which place a direct pressure on aquatic ecosystems and wild fishery resources, a wide range of environmental contaminants, such as chemicals used in farming operations, can accumulate in farmed organisms and put fish health and quality at risk. Thus, as aquaculture makes its transition to a major food-producing sector, proper assessment and control of environmental impacts and food safety awareness are becoming increasingly important. The development of simple tools able to monitor the extent of environmental and biological impacts associated with farming operations at various levels of biological complexity from the ecosystem to the organism level is required. Although a number of techniques for assessing the environmental and biological impact of pollutants in natural ecosystems are available, the development of practical and validated tools is sorely needed in aquaculture.

Focardi, S. (Univ Siena, Dept Environm Sci G Sarfatti, Via Mattioli 4, I-53100 Siena, Italy. Email: focardi@unisi.it), Corsi, I. and Franchi, E. (2005). Safety issues and sustainable development of European aquaculture: new tools for environmentally sound aquaculture. *Aquaculture International*, 13: 3-17.

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14. US study of steroids in fish farm effluents

This study aimed to assess the potential importance of various sources of steroid hormones to surface waters. Water samples were taken from dairy farms, aquaculture facilities and surface waters with actively spawning fish and a suite of androgens, estrogens, and progestins were measured. In a dairy waste lagoon, endogenous estrogens (17beta-estradiol and estrone) and androgens (testosterone and androstenedione) were detected at concentrations as high as 650 ng/L. Samples from nearby surface waters and tile drains demonstrated the sporadic presence of steroids usually at concentrations near or below 1 ng/L. Endogenous steroids (estrone, testosterone, and androstenedione) were detected in the raceways and effluents of three fish hatcheries at concentrations near 1 ng/L. Similar concentrations were detected in a river containing spawning adult Chinook salmon. These results indicate that dairy wastewater, aquaculture effluents, and naturally spawning fish can lead to detectable concentrations of steroid hormones in surface waters and that the concentrations of these compounds exhibit considerable temporal and spatial variation.

Kolodziej, E.P., Harter, T. and Sedlak, D.L. (Univ Calif Berkeley, Dept Civil & Environm Engn, 631 Davis Hall, Berkeley,CA 94720, US. Email: sedlak@ce.berkeley.edu) (2004). Dairy wastewater, aquaculture, and spawning fish as sources of steroid hormones in the aquatic environment. *Environmental Science and Technology*, 38: 6377-6384.

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15. Fish consciousness

There is growing societal and scientific interest in the welfare status of fish used for commercial enterprise. As animal welfare is primarily concerned with the quality of life of a conscious, sentient organism, the question of whether fishes are even capable of consciousness must first be addressed in order to assess their welfare status. Recently, there has been a resurgence of research investigating the biological basis for human consciousness, and our current understanding of the cognitive mechanisms underlying fish behaviour has also improved significantly. Combined, these research perspectives create an opportunity to better comprehend the phylogeny of traits associated with consciousness, as well as the emergence of consciousness itself during vertebrate evolution. Despite the availability of this literature, contemporary reviews or published studies investigating the probability of conscious states occurring in fishes often do so without considering new perspectives or data. In this paper, the authors review and critique recent publications that report equivocal conclusions favouring the absence or presence of consciousness in various fishes. By introducing other data into these analyses, they suggest that there are alternative perspectives which support the existence of consciousness in fishes as a plausible concept. An accurate assessment of the mental capacity of fishes will require enhanced knowledge of their forebrain neuroanatomy, an understanding of how such structures mediate behavioural responses, and an analysis of that information within the context of contemporary theory related to the evolution of consciousness in higher vertebrates.

Chandroo, K.P., Yue, S. and Moccia, R.D. (Univ Guelph, Aquaculture Ctr Dept Anim & Poultry Sci, Guelph, ON N1G 2W1, Canada. Email: rmoccia@uoguelph.ca) (2004). An evaluation of current perspectives on consciousness and pain in fishes. *Fish and Fisheries*, 5: 281-295.

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16. Salmon welfare study

The welfare of fish is receiving increasing attention and attempts have been made to control welfare in farmed fish through regulation of management practices, including stocking density. However, there is little published information on the influence of stocking density on welfare of fish in marine cages. This study examined welfare in Atlantic salmon in cages on a commercial marine farm, exposed to densities ranging from 10 to 34 kg m^3. On three occasions over a period of 10 months, fish were sampled from each cage, weighed and measured; their fin condition assessed and blood samples taken for measurement of glucose and cortisol. A multivariate analysis was used to combine four commonly used measures of fish welfare (condition of body and fins and plasma concentrations of glucose and cortisol) into a single welfare score. As well as objectively reflecting a coherence within the data, this score was consistent with the evaluation of welfare by experienced farmers. A generalized linear model indicated that the welfare score for each cage was significantly related to sampling period, to stocking density (mean over the previous 3 months) and to location of the cage. Further analysis of the relationship between stocking density and the welfare score suggested that there was no trend up to an inflection point ca. 22 kg m^3, after which increasing stocking density was associated with lower welfare scores. This study suggests that, while stocking density can influence the welfare of salmon in production cages, this is only one influence on their welfare and on its own cannot be used to accurately predict or to control welfare.

Turnbull, J. (Univ Stirling, Inst Aquaculture, Stirling FK9 4LA, Scotland. Email: JFT1@STIR.AC.UK), Bell, A., Adams, C., Bron, J. and Huntingford, F. (2005). Stocking density and welfare of cage farmed Atlantic salmon: application of a multivariate analysis. *Aquaculture*, 243: 121-132.

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17. Stress during well boat transport

Many of the disease outbreaks that affect the Norwegian salmon industry take place in the first few months after transfer to sea sites. As stress is known to increase susceptibility to disease, this study monitored physiological stress parameters in salmon smolts through the process of well boat transport to the marine sites. The loading process was found to be a more severe stressor than the transport itself. Only minor plasma cortisol increases were observed during unloading. In four out of five transports, plasma cortisol had returned to resting level at arrival. However in one, which showed an unusually high mortality rate during the first month after transfer to the sea, plasma cortisol levels remained high during unloading. The study showed that well boat transport seemed to have an important recovery function. Without this ability to recover between the stressors of loading and unloading, the ability for salmon smolt to handle multiple stressors was reduced. Further, this study seems to strengthen the fact that some of the increased mortality experienced at sea sites in Norway may be explained by handling and transport prior to delivery of smolt. Care should therefore be taken during commercial boat transport, and planning of well boat routes and avoidance of rough seas could contribute to reducing mortality experienced after transport.

Iversen, M. (Nordland Res Inst, N-8049 Bodo, Norway. Email: martin.iversen@nforsk.no), Finstad, B., McKinley, R.S., Eliassen, RA., Carlsen, K.T. and Evjen, T. (2005). Stress responses in Atlantic salmon (*Salmo salar* L.) smolts during commercial well boat transports, and effects on survival after transfer to sea. *Aquaculture*, 243: 373-382.

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18. Trout slaughter

Electrical stunning in water using a high frequency (1000 Hz) power source is a humane and practical method for killing trout, which results in damage free carcasses. However, the electrical power requirement can be high, particularly with high conductivity water. The equipment needed for the high frequency power supply significantly adds to the capital cost of the equipment and can make such equipment impractical, particularly for use in high conductivity water. A two-stage approach to stunning has been demonstrated which reduces the electrical power required by over 80%. The approach is based on the observation that the electric field strength needed to induce rapid insensibility is greater than the electric field strength required to maintain stunned fish in a state of insensibility until they are beyond the point of recovery. It is further proposed that since the electric field required for the prolonged second stage is quite low, it might be possible to use a 50 Hz power source without causing carcass damage.

Lines, J. (Silsoe Res Inst, Wrest Pk, Bedford MK45 4HS, England. Email: jeff.lines@bbsrc.ac.uk) and Kestin, S. (2005). Electric stunning of trout: power reduction using a two-stage stun. A*quacultural Engineering*, 32: 483-491.

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19. Genetic link to vertebral deformities in salmon

This study examined whether vertebral deformities were linked to parentage. The incidence of vertebral deformities in 44,684 offspring of 225 sires and 471 dams from four different year-classes of Atlantic salmon was observed. The deformities were classified as humpback anterior or posterior to the dorsal fin, or a shortened tail. The average incidence of fish with vertebral deformations was 9.5%, 7.6%, 21.5% and 2.3% in the four year-classes. The water temperatures during egg incubation could not explain the differences between year-classes. Deformed fish were in general lighter, shorter and had a higher and more variable condition factor than nondeformed fish. The estimated heritabilities for deformity shows that vertebral deformity is determined by a substantial additive genetic component. High genetic growth potential was not the cause of the deformity. Inbreeding was not linked to the deformity problems. In view of these results, it is recommended not to select breeders from families with high incidences of deformed fish and, of course, not at all from breeders showing deformities themselves. Such a procedure is not likely to reduce the deformities significantly, but it will prevent the increase in the genetic susceptibility to vertebral deformities in the population. Further efforts should be made to explore the various aetiological causes of the deformities before further critical choices are made.

Gjerde, B. (Inst Aquaculture Res AS, AkVAFORSK, POB 5010, N-1432 As, Norway. Email: bjarne.gjerde@akvaforsk.nlh.no), Pante, M.J.R. and Baeverfjord, G. (2005). Genetic variation for a vertebral deformity in Atlantic salmon (*Salmo salar*). *Aquaculture*, 244: 77-87.

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20. Tank colour effect on stress and growth

The aim of this study was to evaluate the possible anti-stress effect of dietary tryptophan on growth of juvenile rainbow trout reared on different background colours. Fish (4.7g) were reared for 11 weeks in black, light blue and white tanks and fed either a commercial diet (CD) or the, same diet supplemented with tryptophan. Rearing in black tanks led to reduced final weight and total length, lower food consumption, food conversion ratio and body protein, while no differences were observed between fish reared in light blue or white ranks. Feeding the fish tryptophan supplemented diet depressed growth, increased food consumption and food conversion ratio, decreased body protein and increased body lipid, reduced liver total lipids and caused a marked increase in hepatosomatic index (least in fish reared in white tanks). It is concluded that rearing on a black background was stressful for rainbow trout juveniles, while the dietary level of tryptophan used failed as a stress-releasing factor and probably evoked an amino acid imbalance.

Papoutsoglou, S.E. (Univ Agr, Fac Anim Sci Dept Appl Hydrobiol, Iera Odos 75, Athens 11855, Greece. Email: sof@aua.gr), Karakatsouli, N. and Chiras, G.L. (2005). Dietary L-tryptophan and tank colour effects on growth performance of rainbow trout (*Oncorhynchus mykiss*) juveniles reared in a recirculating water system. *Aquacultural Engineering*, 32: 277-284.

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21. Artificial photoperiod affects trout immunity

Artificial photoperiods are widely used in fish culture to alter maturation and enhance growth. This study on rainbow trout investigated a potential side-effect of artificial photoperiod on the ability to combat infection. Trout were exposed to one of three artificial photoperiods: LD 12:12, LD 24:0 and LD: 14:10 and two components of the non-specific immune system were examined. The blood / nitro-blue tetrazolium in vitro method was used to measure production of oxidative radicals and the turbidimetric method to assess plasma lysozyme concentration. A significant reduction in radical production was obtained at 7 days in the LD 24:0 and LD 14:10 groups and an increase in lysozyme concentration was observed in the LD 24:0 photoperiod treatment at 7 days and at 30 days for LD 14:10. The results indicate that artificial photoperiods may affect the immune system of trout and hence their susceptibility to pathogenic microorganisms.

Burgos, A. (Concepcion Univ, Dept Zool, POB 160-C, Concepcion, Chile), Valenzuela, A., Gonzalez, M. and Klempau, A. (2004). Non-specific defence mechanisms of rainbow trout (*Oncorhynchus mykiss*) during artificial photoperiod. *Bulletin of the European Association of Fish Pathologists*, 24: 240-245.

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22. Study of probiotic bacteria in rainbow trout

This study examined the effect on the immune response and gut flora composition of rainbow trout of incorporating a suggested probiotic bacteria (*Lactobacillus rhamnosus* JCM 1136) into a commercial feed. The probiotic bacteria were incorporated into two experimental diets containing either 109 or 1011 colony forming unit of live bacteria/ g of feed while a third diet without the bacterial supplement served as a control diet. The diets were fed to rainbow trout (75 g average weight) in triplicate tanks for 30 days. The serum lysozyme and complement activities were significantly greater in fish fed the higher level of probiont compared with the control fish. The phagocytic activity of head kidney leucocytes also showed similar tendencies. These observations indicate the potential immuno-regulatory role of probiotic organisms in rainbow trout.

Panigrahi, A., Kiron, V. (Bodo Univ Coll, Dept Fisheries & Nat Sci, N-8049 Bodo, Norway. Email: kiron.viswanath@hibo.no), Kobayashi, T. Puangkaew, J., Satoh, S. and Sugita, H. (2004). Immune responses in rainbow trout *Oncorhynchus mykiss* induced by a potential probiotic bacteria *Lactobacillus rhamnosus* JCM 1136. *Veterinary Immunology and Immunopathology*, 102: 379-388.

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23. Carbon dioxide production by biofilters

In this study, the fluidized-sand biofilter in a commercial-scale recirculating salmonid culture system produced 4.1 mg/L of CO_2 and removed 3.8 mg/L dissolved O_2 while removing 0.5 mg/L total ammonia nitrogen. Because the fish produced 6.9 mg/L of CO_2 during the same period, then the biofilter accounts for 37% of the total CO_2 produced within this recirculating system. Therefore, the CO_2 stripping unit should be placed immediately after the biofilter simply as common sense to optimise water quality. If the stripping unit were placed before the biofilter, then the fish would experience a CO_2 concentration that would be at least 20% greater than if the stripping unit were placed immediately after the biofilter.

Summerfelt, S.T. (Conservat Funds Freshwater Inst, 1098 Turner Rd, Shepherdstown, WV 25443, USA. Email: s.summerfelt@freshwaterinstitute.org) and Sharrer, M.J. (2004). Design implication of carbon dioxide production within biofilters contained in recirculating salmonid culture systems. *Aquacultural Engineering*, 32: 171-182.

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24. New CO_2 scrubber

In recirculating water culture systems, CO_2 is typically removed by air stripping. This process requires a significant energy input for forced air movement, air heating in cold climates and water pumping. This study developed a modification for a spray tower that provides for carbon dioxide desorption as well as oxygen absorption. Elimination of the air-stripping step reduces pumping costs while allowing dissolved nitrogen to drop below saturation concentrations. This latter response provides for an improvement in oxygen absorption efficiency within the spray tower. CO_2 desorption is achieved by directing head-space gases (O_2, N_2, CO_2) from the spray tower through a sealed packed tower scrubber receiving a NaOH solution. Carbon dioxide is selectively removed from the gas stream, by chemical reaction, forming the product Na_2CO_3. Scrubber off-gas, low in CO_2 but rich in O_2 is redirected through the spray tower for further CO_2 stripping and O_2 absorption. NaOH is metered into the scrubbing solution sump on an as needed basis by a feedback control loop programmed to maintain a scrubbing solution pH of 11.4-11.8. The spent NaOH solution is collected, then regenerated for reuse, in a batch process that requires relatively inexpensive hydrated lime. Given the enhanced gas transfer rates possible with chemical reaction, the required NaOH solution flow rate through the scrubber represents a fraction of the spray tower water flow rate. Further, isolation of the water being treated from the atmosphere allows for an improvement in oxygen absorption efficiency by maintaining N_2 well below local saturation concentrations, minimizes building energy requirements related to heating and ventilation and reduces the potential for pathogen transmittance. The performance of a test scrubber in a pilot scale recirculating water trout production system is reported.

Watten, B.J. (US Geol Survey, Leetown Sci Ctr, 11649 Leetown Rd, Kearneysville,WV 25430, USA. Email: barnaby_watten@usgs.gov), Sibrell, P.L., Montgomery, G.A. and Tsukuda, S.M. (2004). Modification of pure oxygen absorption equipment for concurrent stripping of carbon dioxide. *Aquacultural Engineering*, 32: 183-208.

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25. New source of marine fatty acids

At present specific fatty acids known to benefit human health are mainly available via consumption of fish, which is a limited and endangered resource. Three recent reports (Baoxiu Qi *et al*., Amine Abbadi *et al*. and Anthony J. Kinney *et al*.) describe the production of very long-chain polyunsaturated fatty acids in transgenic plants. This might lead to a sustainable source of these valuable fatty acids for use in human food and animal feed.

Domergue, F. (Univ Hamburg, Biozentrum Klein Flottbek, Ohnhorststr 18, D-22609 Hamburg, Germany. Email: fredomergue@voila.fr), Abbadi, A. and Heinz, E. (2005). Relief for fish stocks: oceanic fatty acids in transgenic oilseeds. *Trends in Plant Science*, 10: 112-116.

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26. A novel protein source for fish diets

Bacterial protein meal (BPM) produced on natural gas was evaluated with respect to growth, survival, body composition and histopathological indices in Atlantic salmon during the freshwater stage. Bacterial protein replacing high-quality fish meal in the experimental diets, accounting for 0%, 6.25%, 12.5%, 25% and 50% of total dietary amino acids. Each diet was fed to salmon for 1 year from first feeding. In addition, a digestibility experiment was carried out. Growth and survival were not significantly different for fish fed the fish meal control diet and diets with bacterial protein replacement up to 25%. For the highest replacement level, growth and survival were reduced. Gut to body weight ratio and whole body fat increased with increasing bacterial protein inclusion in a curvilinear manner. The histological evaluation showed no systematic difference in tissue morphology between the two dietary groups (6.25% and 50% bacterial protein) examined. The apparent digestibility of nitrogen from the bacterial protein was 78.4%. The digestibility of fat was reduced in a curvilinear manner with increasing inclusion of bacterial protein. In conclusion, the results indicate that bacterial protein can replace up to 25% of the amino acids from high-quality fish meal in a diet for juvenile salmon in freshwater, but that both growth and survival were negatively affected at an inclusion rate as high as 50%.

Storebakken, T., Baeverfjord, G., Skrede, A., Olli, J.J. and Berge, G.M. (AKVAFORSK, POB 203, N-6600 Sunndalsora, Norway. Email: gerd.bergc@akvaforsk.nlh.no) (2004). Bacterial protein grown on natural gas in diets for Atlantic salmon, *Salmo salar*, in freshwater. *Aquaculture*, 241: 413-425.

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27. Evaluation of triploid "brownbow"

This study tested the farming performance of triploid hybrids between female rainbow trout and male brown trout, with reference to parental species. The main drawback of hybrids lay in embryonic and larval mortalities, amounting to 60% on average, and displaying a large variability between batches. Further survival was inferior to that of diploid, but similar to that of triploid rainbow trout. Hybrid body weight was intermediate between weights of rainbow and brown trout of the same age, mainly as a consequence of differences in precocious growth. Analysis of relative growth rates from 6 to 18 months showed that hybrids were surpassed by rainbow controls when reared together, but not when reared separately. Hybrid behaviour was similar to that of rainbow trout. These results are discussed in the scope of providing fisheries managers with original and sterile game fishes.

Blanc, J.M. (INRA, Unite ECOBIOP, F-64310 St Pee Sur Nivelle, France. Email: jmb@st-pee.inra.fr) and Maunas, P. (2005). Farming evaluation of the "brownbow" triploid hybrid (*Oncorhynchus mykiss* x *Salmo trutta*). *Aquaculture International*, 13: 271-281.

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28. Social status in salmonids

Social interactions in small groups of juvenile rainbow trout lead to the formation of dominance hierarchies. Dominant fish hold better positions in the environment, gain a larger share of the available food and exhibit aggression towards fish lower in the hierarchy.
By contrast, subordinate fish exhibit behavioural inhibition, including reduced activity and feeding. The behavioural characteristics associated with social status are likely to be due to changes in brain monoamines resulting from social interactions. Whereas substantial

physiological benefits, including higher growth rates and condition factor, are experienced by dominant trout, low social status appears to be a chronic stress, as indicated by sustained elevation of circulating cortisol concentrations in subordinate fish. High cortisol levels, in turn, may be responsible for many of the deleterious physiological consequences of low social status, including lower growth rates and condition factor, immunosuppression and increased mortality. Circulating cortisol levels may also be a factor in determining the outcome of social interactions in pairs of rainbow trout, and hence in determining social status. Rainbow trout treated with cortisol were significantly more likely to become subordinate in paired encounters with smaller untreated conspecifics.

Gilmour, K.M. (Univ Ottawa, Dept Biol, 150 Louis Pasteur, Ottawa, ON K1N 6N5, Canada. Email: katie.gilmour@science.uottawa.ca), Dibattista, J.D. and Thomas, J.B. (2005). Physiological causes and consequences of social status in salmonid fish. *Integrative and Comparative Biology*, 45: 263-273.

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29. Stocking brown trout

This Swedish study examined the effect of a resident wild population of brown trout on the success of stocked fish. Hatchery-reared brown trout stocked into a natural stream in addition to resident wild brown trout grew more slowly than those stocked with an experimentally reduced density of brown wild trout. In both cases, the hatchery-reared brown trout grew more slowly than resident wild fish in control sections. Mortality and movements did not differ among the three categories of fish. The results showed that growth of stocked hatchery-reared brown trout parr was density-dependent, most likely as a consequence of increased competition. Thus, supplementary release of hatchery-reared fish did not necessarily increase biomass.

Sundstrom, L.F. (Univ Gothenburg, Dept Zool, Box 463, SE-40530 Gothenburg, Sweden. Email: fredrik.sundstrom@zool.gu.se), Bohlin, T. and Johnsson, J.I. (2004). Density-dependent growth in hatchery-reared brown trout released into a natural stream. *Journal of Fish Biology*, 65: 1385-1391.

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30. Escaped salmon in Scotland

This study assessed the prevalence of escaped farmed Atlantic salmon in the River Ewe, western Scotland. Since the establishment of smolt cages in the catchment and marine cages near the river mouth during 1986-1987, an estimated 425 000 parr and smolts, and 122 000 growers have escaped. Between 1987 and 2001, farmed fish were caught in the rod fishery in 13 of the 15 years, contributing at least 5.8% of the total catch, with a maximum annual frequency of 27.1%. It was estimated that although only a very small proportion (<1%) of escapees from the marine cages did enter the river, these fish contributed at least 27% to the potential anadromous spawners in 1997. Farmed fish radiotagged in 2001 were thought to have spawned in three subcatchments also used by tagged wild fish. Despite the likelihood of hybridisation there was no change in the median weight or marine age of wild fish, although smolt age did decrease significantly. As the Ewe has a depleted wild salmon population (≤900 anadromous adults), it is recommended that further genetic introgression by escapees should be prevented.

Butler, J.R.A. (Wester Ross Fisheries Trust, Harbour Ctr, Gairloch, Rossshire, Scotland. Email: director@speyfisheryboard.com), Cunningham, P.D. and Starr, K. (2005). The prevalence of escaped farmed salmon, *Salmo salar* L., in the River Ewe, western Scotland, with notes on their ages, weights and spawning distribution. *Fisheries Management and Ecology,* 12: 149-159.

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31. Spanish study of hybridisation between native and stocked fish

Genetic changes in the population structure of brown trout in the eastern Pyrenees were monitored during the 1990s. Stocking with cultivated exogenous fish has resulted in hybridised populations. This increase in local genetic diversity is thought to reflect a decrease of genetic differentiation between populations and loss of native alleles. These changes obscure native gene pools and modify evolutionary distinctions among native brown trout populations.

Araguas, R.M. (Univ Girona, Lab Ictiol Genet, Campus Montilivi S-N, E-17071 Girona, Spain. Email: rosa.araguas@udg.es), Sanz, N., Pla, C. and Garcia-Marin, J.L. (2004). Breakdown of the brown trout evolutionary history due to hybridization between native and cultivated fish. *Journal of Fish Biology*, 65: 28-37.

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32. Belgian study of hybridisation between native and stocked fish

Brown trout populations in the Belgian rivers Scheldt and Meuse have been intensively stocked in the past decades, often with fish of uncertain origin. Moreover, the species habitat has become increasingly fragmented, preventing gene flow between neighbouring populations. This study assessed how genetic diversity and population structure had been affected by analysing 12 wild populations (total n=309) and seven hatchery stocks (n=200). Historical records indicate that brown trout from distant locations have been used to supplement hatchery stocks; nevertheless we detected non-Atlantic mitochondrial genomes in only one population of the Scheldt basin and in one hatchery. In general, the hatchery samples displayed a higher genetic diversity and differentiated less among each other compared to the wild populations. This is interpreted as being due to frequent exchanges between hatcheries and regular supplementation from several indigenous populations. Gene pools present in most downstream sections from tributaries of the Meuse were similar to each other and to the hatchery samples, despite the presence of migration barriers. Assignment analyses indicated that the contribution of hatchery material to the upstream parts was limited or even completely absent in populations separated by a physical barrier. Intensive stocking and exchange between hatcheries has homogenized the downstream sections of the Meuse River, whereas the migration barriers have preserved the indigenous upstream populations. As such, uncontrolled removal of barriers might result in an irreversible loss of the remnant indigenous gene pools.

Van Houdt, J.K.J. (Katholieke Univ Leuven, Aquat Ecol Lab, Ch Beriotstr 32, B-3000 Louvain, Belgium. Email: jeroen.vanhoudt@bio.kuleuven.ac.be), Pinceel, J., Flamand, M.C., Briquet, M., Dupont, E., Volckaert, F.A.M. and Baret, P.V. (2005). Migration barriers protect indigenous brown trout (*Salmo trutta*) populations from introgression with stocked hatchery fish. *Conservation Genetics*, 6: 175-191.

33. Fish hypnosis

This study found that an immobility reflex can be induced in fish by a vigorous flow of water through the branchial chamber. The reflex was observed in 22 species representing bony and cartilaginous fishes from diverse habitats, and was invariably characterised by loss of caudal muscle tone and limp posture. The critical flow rate for induction increases with increasing body size. The immobilised state may be maintained for many hours, with the heart rate falling to below the resting rate, and revival is instantaneous. In addition, haematological parameters, and plasma lactate after 6 h were typical of resting fish. Although the mechanism is unclear, and the selective advantage for the fish unknown, pressure-sensitive receptors in the branchial chamber are likely to be involved. Application in live fish transport, and recovery from handling and exercise stressors is suggested.

Wells, R.M.G. (Univ Auckland, Sch Biol Sci, Private Bag 92019, Auckland 1, New Zealand. Email: r.wells@auckland.ac.nz), McNeil, H. and MacDonald, J.A. (2005). Fish hypnosis: Induction of an atonic immobility reflex. *Marine and Freshwater Behaviour and Physiology*, 38: 71-78.

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