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

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TROUT PRODUCTION

2003 SURVEY OF TROUT PRODUCTION IN ENGLAND AND WALES

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During the first half of 2004, the inspection and monitoring programme of salmonid farms, undertaken on behalf of Defra and the Agriculture Department of the National Assembly for Wales under the European Council Directive 91/67/EC, was carried out. A total of 252 registered salmonid farm sites were visited during the period. Of these, 8 sites recorded no sales of fish during 2003 but have continued to hold stock and one site had an ownership change and therefore no accurate data was available. In addition two new farms were registered and eight sites ceased trading and were de-registered 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 251 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 2003
2) Sites that produce rainbow trout for the table market only
3) Sites that produce rainbow trout for restocking fisheries and/or for ongrowing
4) Sites that cater for both table and restocking/ongrowing markets.

The total annual production of rainbow trout for the table market in 2003 was 6,143 tonnes from 86 farm sites. This figure is a slight fall compared to 2002 (6,357 tonnes). A total of 178 farms produced rainbow trout for restocking fisheries or ongrowing purposes, a decrease of 3 sites on the 2002 numbers. These sites together produced 3,156 tonnes during 2003, of which 2,771 tonnes were restocking trout and 385 tonnes were fingerlings or yearlings for ongrowing. This figure represents almost a 5% decrease on the total restocking and ongrowing production recorded for 2002 (3,302 tonnes). The recorded production of rainbow trout for the table market decreased by 3% from last year while restocking production decreased by 5%. The production of rainbow trout fry has returned to levels previously seen after a dramatic decline in 2002.

The overall rainbow trout production (combining table and restocking/ongrowing figures) for England and Wales in 2003 was 9,299 tonnes, a decrease of 360 tonnes on 2002 production. This figure is close to the level of production reached prior to the Foot and Mouth Disease outbreak in 2001. In 2002 table fish production decreased by 3%, while restocking production increased by 17% on the previous years

Table 1. 2003 Rainbow trout production by Environment Agency Region for England and Wales

Environment Agency Area	Number Of Sites					Production		
	No Production	Table Production	Restocking/ Ongrowing Production	Both (Table & Restocking)	Total number of sites	Table (tonnes)	Restock/ Ongrowing (tonnes)	Fry (thousands)
Anglian	1	1	7	3	12	16	200	632
North East	1	7	17	8	33	1,082	505	9,424
North West	1	1	6	7	15	94	131	44
Midlands	2	1	11	1	15	5	270	50
Southern	3	7	17	2	29	1,520	174	282
South West	2	9	35	22	68	2,668	1,361	8,644
Thames	1	2	8	7	18	560	286	500
Welsh	1	2	21	6	30	198	229	2,318
Totals	12	30	122	56	220	6,143	3,156	21,893

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

Environment Agency Area	Production according to farm output category (tonnes)				
	0-10	11-50	51-100	101-200	>200
Anglian	6 (6)	150 (6)	80 (1)	0 (0)	0 (0)
North East	40 (14)	287 (11)	414 (6)	299 (2)	621 (2)
North West	21 (9)	103 (5)	123 (2)	0 (0)	0 (0)
Midlands	25 (10)	100 (4)	61 (1)	132 (1)	0 (0)
Southern	36 (18)	220 (10)	0 (0)	0 (0)	1,500 (4)
South West	77 (26)	731 (30)	877 (12)	545 (3)	2,171 (3)
Thames	21 (8)	151 (6)	139 (2)	112 (1)	450 (2)
Welsh	48 (20)	235 (11)	166 (2)	0 (0)	0 (0)
Totals	274 (111)	1,977 (83)	1,860 (26)	1,088 (7)	4,742 (11)
% Total Production	2.8	19.9	18.7	10.9	47.7
% Farms involved	46.6	34.9	10.9	2.9	4.6

figures. Overall, the data indicates that the industry is stabilising, large percentage changes in production appear to have ceased and there may well follow a period of stability.

Table 2 provides a breakdown of trout production where farms are classified according to their scale of production. Data for brown trout production are also included because the majority of brown trout are produced from sites also farming rainbow trout. Just under 47% of the trout farms in England and Wales are in the 0-10 tonnes category but their combined output only accounts for 2.8% of total production, which is a decrease from 2002 levels in both cases. The number of the smallest registered farms (0-10 tonne) has decreased by 15 sites from 2002, and it is mainly these sites which have become de-registered during the year. Meanwhile the numbers of slightly larger (11-50 tonne) farms and the largest farms (>200 tonnes) have both increased, with the largest rise in the smaller of these two categories. The biggest farms (those producing > 200 tonnes annually) account for just over 47% of total trout production but form 4.6% of the total number of trout farms in England and Wales. This is slightly higher than the 2002 levels, suggesting an optimistic outlook for the future. The South West area contains the highest number of farms (74) and produces the most trout of any region (almost 45% of trout production) in England and Wales.

Production of other farmed salmonids

The 2003 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 252 registered salmonid farms producing fish during 2003, 116 sites produced brown trout in addition to rainbow trout and 15 sites produced brown trout only (a total of 131 sites – an increase of 1 site from 2002). Ten farms produced both trout and Atlantic salmon, 15 sites concentrated on producing salmon alone, while 1 farm failed to produce any salmon. Total production of brown trout in England and Wales has decreased to 642 tonnes (from 683 tonnes in the 2002) which includes 300 tonnes of brown trout produced for the table. Six sites held brook trout (*Salvelinus fontalinus*), but only three sites recorded production in 2003 - 1.75 tonnes for the table market and 30 thousand fry for ongrowing. Three sites held Arctic char (*Salvelinus alpinus*) over the period but there was no reported production of this species - it appears that production trials for this species have been unsuccessful.

Commercial units that supply farms in Scotland produced the majority of salmon smolts. A total of 1.7 million smolts were produced from 7 sites, which represents a decrease from 2002 (2.2 million smolts from 12 sites). Six commercial sites also produced just over 340 thousand salmon parr, both increases on 2002 data, suggesting a possible change in trading patterns. In addition, 5 Environment Agency salmonid rearing sites operated during 2003 to produce fry and juvenile salmon for specific river stock enhancement programmes. These sites together produced almost 82 thousand salmon smolts, 225 thousand salmon parr, almost 468 thousand salmon fry and 167 thousand sea trout fry. The number of salmon smolts produced by the EA sites has decreased by 22% and the numbers of fry produced has fallen 31%, but the numbers of sea trout has dramatically increased by just over 100 thousand fry on last years production. The changes in production from these sites suggest that the emphasis of salmon

Table 3. 2003 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	7	4	19	22	2	0	180	682
North East	19	15	75	90	3	0	350	300
North West	7	4	22	78	5	0	1,488	2,630
Midlands	11	10	42	81	1	0	111	0
Southern	26	20	60	100	3	0	0	305
South West	35	23	73	794	2	0	0	0
Thames	11	9	29	390	3	0	37	0
Welsh	15	11	22	14	6	0	244	497
Totals	131	96	342	1,569	25	0	2,410	4,414

Plus 300t of brown trout for the table market

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 returned to previous levels after a large increase in 2002. The emphasis on brown trout stock management appears to have returned to enhancing the stock of juvenile fish in river systems, which is unusual compared to previously reported production data.

Ova production

The recorded figures for salmonid ova produced over the period running from late 2003 through to early 2004 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 11.7 million eggs, of which almost 3.4 million were sold to other sites. These figures represent a decrease from the 2002/2003 season (20.5 million eggs). Mixed-sex rainbow trout egg production has decreased to almost 1.3 million eggs from last years level of almost 2.1 million. The recorded production of rainbow trout triploid eggs was almost 6.5 million, which is a decrease from the 2002/2003 level of just under 9.7 million. Production of both triploid and mixed-sex rainbow trout eggs has declined. Overall rainbow trout egg production has declined by almost 40%, from 32.4 million eggs in 2002/2003 to 19.4 million for this period.

The majority of brown trout ova produced were mixed-sex and production totalled just over 3.5 million ova, a decrease of almost half a million eggs on last years figures. Of this total, just over 2 million were sold to other sites. A total of 323 thousand all-female brown trout ova were produced, a very slight decrease from

Table 4. 2003/2004 eyed ova production from sites holding broodstock salmonids in England and Wales (not including sea trout and salmon produced from wild broodstock by the EA)

	Rainbow trout			Brown trout			Salmon
Environment Agency Area	All Females (thousands)	Mixed Sex (thousands)	Triploid (thousands)	All Females (thousands)	Mixed Sex (thousands)	Triploid (thousands)	Mixed Sex (thousands)
Anglian	0	0	0	0	100	0	0
North East	3,110	572	2,069	100	57	641	0
North West	0	0	0	0	715	0	881
Midlands	0	0	0	0	257.5	0	0
Southern	70	5	0	15	138	15	0
South West	8,007	647	4,120	148	920	321	0
Thames	310	0	300	60	1,106	160	0
Welsh	180	50	0	0	232	0	187
Totals	11,677	1,274	6,489	323	3,525	1,137	1,068

last years levels (356 thousand eggs). Triploid ova production was recorded as 1.1 million – doubling the previous years figure of 567 thousand. This is the second year in succession that triploid ova production has doubled. Overall production of brown trout eggs has only increased slightly, this 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.

Just over one million salmon eggs were produced by commercial salmon rearing sites, which is a slight increase from 2002 levels. A further 300 thousand eggs were produced for Environment Agency stock enhancement programmes, a decrease of around 300 thousand eggs from last years levels. In addition, just over one million eggs from salmon broodstock obtained from rivers around England and Wales were laid down by commercial hatcheries, in co-operation with the Environment Agency, and reared to produce parr for local stock enhancement schemes. This represents an increase of 17% in activity on behalf of the EA.

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

2003 RAINBOW TROUT EGG IMPORTS INTO ENGLAND AND WALES

Summary of rainbow trout eggs imported into England and Wales by month in 2003

Month	Northern Ireland (thousands)	Isle of Man (thousands)	Denmark (thousands)	USA (thousands)	Total (thousands)
January	0	1,100	1,270	0	2,370
February	0	350	900	100	1,350
March	0	1,140	930	0	2,070
April	0	500	1,630	100	2,230
May	0	75	795	0	870
June	0	0	500	800	1,300
July	0	400	0	2,745	3,145
August	0	0	0	1,850	1,850
September	20	15	0	1,625	1,660
October	0	100	0	1,160	1,260
November	0	140	0	880	1,020
December	20	1,055	1,600	200	2,875
Total	40	4,875	7,625	9,460	22,000
Total %	0.2	22.2	34.7	43.0	100

Rainbow trout egg imports into England & Wales during 2003 totalled 22 million.
This is a significant decrease on the number of eggs imported from the previous year (54.6 million).

TROUT ARTICLES

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

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The following report covers the presentations given on the second day of last year's Sparsholt Conference. The first day's presentations were reported in the January 2004 issue of *Trout News*.

Feeding Strategies

Chris Beattie from Skretting talked on 'Feeding strategies'. He started by stating that for fish farmers to achieve the profit margin required to survive in the increasingly competitive industry of today, production costs need to be minimised. As feed is a major contributory factor to the cost of trout production, there is pressure to achieve the optimum feed to growth ratio. The farmer also has to meet the demands of the market place for delivery of fish at the correct size, quality, quantity and time, all of which can vary. The farmer therefore needs to balance minimising feed input costs with controlling growth to meet market demand. The farmer therefore requires the correct data and skill level to implement feeding strategies to not only maximise, but also manipulate, growth.

An integral part of a feed strategy is the actual feed supplied, and feed companies now supply an increasing variety of different feeds. The other component of a strategy is how much food is to be provided to the fish and when. A number of different feeding strategies have emerged including feed tables, growth models and demand/appetite feeding. Appetite feeding is becoming increasingly common on farms, the aim being to enhance the financial benefit by maximising growth potential and reducing crop cycle times. A number of sub-surface pellets sensing systems are being introduced which enable farmers to accurately gauge the satiation point of the fish.

Although satisfactory results can be obtained by using either appetite feeding or feed tables, a number of additional factors also need to be taken into consideration to totally understand fish feed requirements. Environmental factors such as oxygen levels, photo-period, stress and health status can result in significant deviation from predicted models. These factors vary, in some cases on an hourly basis, and can affect feeding and modify the potential growth rate. If information on the influence of such factors is collected, it can be used in both long-term and short-term feeding strategies. It is paramount that this input data is of the highest quality, and the interpretation of the data is the key to obtaining reliable control of growth. Therefore, the skills of the farm staff in recording such factors, then reviewing and applying the data collected cannot be understated, as it can have a positive or negative effect on the growth rate of the stock.

Welfare and Disease

The next session focused on Welfare with Tim Ellis (CEFAS Weymouth) and Ben North (Institute of Aquaculture, Stirling) talking on stocking density and Jeff Lines (Silsoe Research Institute) talking on humane slaughter. These three talks are included as full articles, either in this or the previous issue of *Trout News*. After lunch there was the traditional Friday afternoon disease session. Alasdair Scott (CEFAS Weymouth) spoke on 'Sleeping Disease: a lesson in biosecurity', and Niels Henrik Henriksen (association of Danish Trout Farmers) talked on 'RTFS - experiences from Denmark'. Both these talks were published as full articles in the previous edition of *Trout News*.

PKD and bryozoa

The conference concluded with Charles McGurk (Institute of Aquaculture, Stirling) giving a talk, very well illustrated with video images, entitled 'The relationship between PKD and Bryozoa: an inside story'. He started by introducing the disease and its life cycle. Proliferative Kidney Disease (PKD) was named by Roberts and Shepherd in 1974. The causative organism of PKD is a parasite that causes renal hypertrophy. In advanced cases these gross kidney changes can be seen macroscopically. The disease causes huge losses in North America and Europe. In the UK alone the annual cost to the trout industry is over £1 million. Originally the causative organism was known as PK'X'. However, since the recent discovery of the other life stages in bryozoans (or 'moss animals') which act as intermediate hosts, the organism has now been properly identified as a malacosporean and named *Tetracapsuloides bryosalmonae*.

Within the trout, the parasite has an incubation period of about 7 weeks, depending on temperature, before gross clinical signs and losses occur. Clinical signs include: darkening of the body, abdominal swelling and mortalities. Affected fish often swim abnormally, gasp at the water surface and show adverse reaction to any stress. Parasite proliferation in the kidney leads to inflammation and nephromegaly, resulting in extensive mortalities which can be up to 100%. Diagnosis is confirmed by histological examination of kidney tissue. Immunohistochemistry is being used more frequently to detect the 'mother', 'daughter' and 'grand-daughter' parasite cells. Fish that do recover usually do so 10-12 weeks after infection and are immune to subsequent challenge.

In the life cycle of the parasite the fish is the vertebrate host and bryozoans are the invertebrate hosts. Infectious spores released from bryozoans invade the fish through the gills and skin, travel through the circulatory system, and eventually reach the inner organs, mainly kidney and spleen. Here they develop into exosporogonic stages within the interstitial tissue where propagation takes place. The host reacts with a pronounced proliferation of the interstitial tissue (inflammation), which may result in a considerable enlargement of the affected organs. From the interstitial tissue the parasites move into the kidney tubules where they transform into sporogonic stages.

Bryozoans are sessile, filter-feeding animals that live in freshwater attached to various hard, submerged surfaces. Research work at Stirling University has included trials to assess suitable foods for these bryozoans so that they can be maintained for infectivity trials. The findings suggest that the microscopic algae *Botrydium granulatum* is a particularly digestible food source. A low maintenance experimental set-up has now been developed which should enable more detailed studies in the future.

T. bryosalmonae (PKD organism) collected from PKD affected trout farms, have been studied within the bryozoans using light and electron microscopy, with video image capture. The PKD organism, *T. bryosalmonae*, was observed developing as irregular ball-like spore sacs with projections. The infection destroys the bryozoan morphology and definition is lost between zooids. A related species, *Buddenbrockia*, was observed to effectively over-winter within the statoblasts (seeds) of the bryozoan.

The successful laboratory culture of the bryozoans has enabled year round production of the parasite. Successful transfer between bryozoa and trout has subsequently been shown and there are plans to develop controlled infection models that will allow the comprehensive study of myxozoan infection in the hosts. This will have the potential to fill in the missing links of the life cycle and will hopefully assist the development of a PKD vaccine.

STOCKING DENSITY AND RAINBOW TROUT WELFARE: WHAT DOES THE LITERATURE TELL US?

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Ben North, the late Niall Bromage and James Turnbull, Institute of Aquaculture, University of Stirling, FK9 4LA

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

Background

There is increasing interest in the welfare of farmed fish, and stocking density is frequently highlighted as an area of particular concern (1). In its 1996 report on the Welfare of Farmed Fish (2), the Farm Animal Welfare Council (FAWC) suggested that rainbow trout on commercial farms in the UK suffered "*a high incidence of fin injury*" and "*high mortality*", which were linked to high stocking density. The issue of stocking density of fish is complex because it combines the behavioural need for space with the physiological need for water (to provide oxygen and dilute and remove waste products). The FAWC report recognised this and the likely importance of environmental factors by stating that "*Many factors such as oxygen level, fish size, water temperature, water flow, available space, carbon dioxide and ammonia levels affect the acceptability of stocking densities" and that "It is a highly complex task to set a maximum stocking density for trout*". Nevertheless, the report suggested that 30-40 kg/m^3 was too high a stocking rate for trout, and that research should be undertaken to determine acceptable stocking densities.

The government responded to the FAWC report (3) and commissioned research into the effects of stocking density on rainbow trout. A collaborative project between CEFAS Weymouth and the Institute of Aquaculture, University of Stirling was funded by Defra with support from the BTA. The overall aim of the project was to improve knowledge on relationships between density and trout welfare. This was to be accomplished via a review of the literature, laboratory experiments and sampling on commercial trout farms. Here we present a summary of a literature review that has been published in full elsewhere (4). Some of the experimental work is presented in the succeeding article (5).

Assessing welfare in relation to stocking density

There is much discussion as to what welfare means and how it can be assessed (6). Welfare is generally accepted to mean the absence of suffering, but as suffering is subjective it is difficult to assess. There is also debate as to whether fish have the capacity to experience suffering (7). Dawkins (8) recently suggested that welfare (as applied to production) could be simplified into two questions:

- are the animals healthy?
- do they have what they want?

These two questions address what most people consider to be welfare, and indicate the information needed to assess welfare.

Due to the importance of stocking density as a husbandry factor, a considerable amount of research investigating the effects on rainbow trout has already been conducted. Although welfare was not examined explicitly in these 45 experimental studies, the data on various production, condition and stress parameters can be used to address Dawkins' two questions.

Are the animals healthy?

Mortality is a key indicator of health status. Of the 23 studies that have assessed the effects of density on mortality, 42% found an adverse effect, with mortality increasing with increasing density (4, Figure 1). Therefore, although there is a tendency for mortality to increase with increasing density, a higher mortality is not a generic effect of higher density in such experimental systems. This data set gives no indication of an appropriate maximum density, with overlapping density ranges for studies finding either adverse or no effects of density on mortality. The actual causes of mortality were generally not documented. However, cases of episodic mass mortalities due to system (oxygenation, water supply) failures illustrate that higher densities require greater supervision (9, 10). An increase in disease with increasing density was rarely recorded in these experimental studies. However, single studies have demonstrated suppression of an immunological parameter, i.e. a reduction in the numbers of white blood cells (11), and an increase in disease transmission with increasing density (12). This latter study indicated that stocking density only affected mortality when the infective pressure was low (Figure 2).

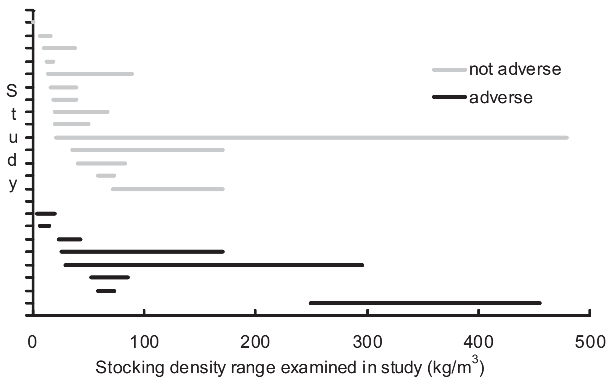

Figure 1. Effect of density on mortality of rainbow trout. Length and position of horizontal lines above X-axis indicate density ranges examined within individual studies, and shade of lines indicate whether an adverse effect of increasing density was recorded

Fin erosion is a health issue as it represents damage to tissues. Of the seven studies assessing fin erosion, 71% have found an adverse effect of increasing density. This common experimental finding was confirmed by a field survey of US farms (13). However, although higher densities were associated with increased fin erosion in this field study, other environmental factors – water alkalinity, a concrete substratum, and ammonia levels - were found to have a greater effect. Despite numerous studies on fin erosion, the actual cause remains unclear. Increasing aggressive behaviour (nipping), increasing non-aggressive behaviour (abrasion, accidental nipping) and poor water quality have all been suggested as the causes of increased erosion at higher densities.

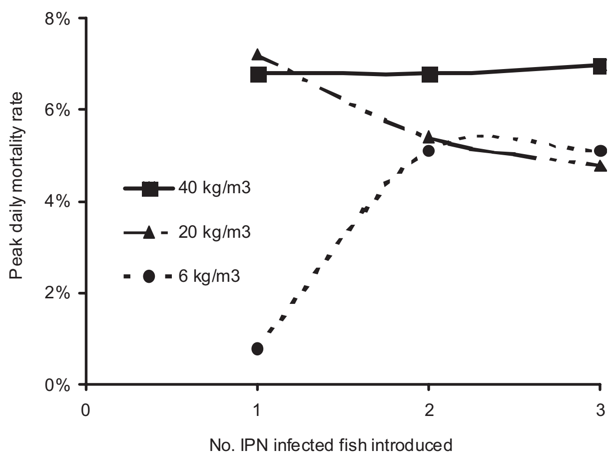

Figure 2. Effect of stocking density on mortality of rainbow trout from IPN (Data from 12). Mortality was greater at the two higher stocking densities when only 1 IPN infected fish was introduced, but there was no difference between densities when more infected fish were introduced to the tank population

Do they have what they want?

Fish have environmental requirements and if these are not met, then there will be a physiological response. A commonly used physiological measure in farm animal welfare studies is the level of cortisol, the classic stress hormone, present in the blood. Of the seven studies that have examined cortisol levels in relation to increasing density, only two reported an adverse effect. The first study (11) found a transient increase in cortisol level for the first week after transfer to a higher stocking density. A subsequent study by the same authors (14) also found a higher blood cortisol level in a higher density group, but this was related to season and dissolved oxygen levels (Figure 3), rather than density itself. Other stress response indicators have been examined with little evidence for a stress response to increasing density (4).

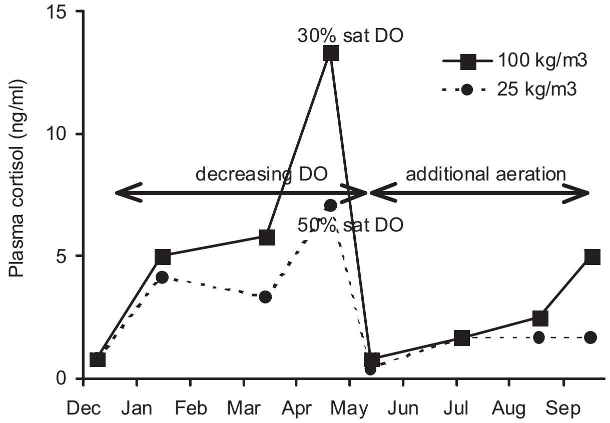

Figure 3. Blood cortisol levels in rainbow trout exposed to two different stocking density over a nine month period. Dissolved oxygen levels were found to be different in April, and following provision of additional aeration, the difference in cortisol levels disappeared. Redrawn from (14)

A chronic response to an inadequate environment can perhaps best be assessed from measures of growth, body condition, and growth efficiency. Reduced growth (Figure 4) and condition indices (body and liver), and an increased food conversion ratio in response to increasing density were found in 70% of studies (4). However, again this data set gives no indication of an appropriate maximum density, with overlapping density ranges for studies finding either adverse or no effects of density on growth (Figure 4). There is currently little agreement on the cause of the reduction in growth with increasing density, and the various suggestions are:

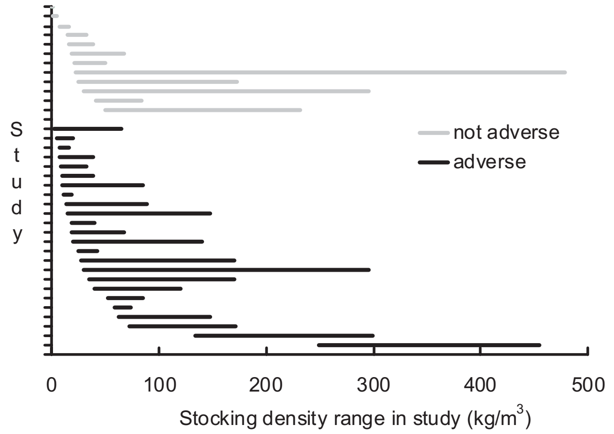

Figure 4. Effect of density on growth of rainbow trout. Length and position of horizontal lines above X-axis indicate density ranges examined within individual studies, and shade of lines indicate whether an adverse effect of increasing density was recorded

- a reduction in space leading to
  - crowding stress, or
  - an increase in aggressive behavioural interactions, or
  - an increase in non-aggressive behavioural interactions, or
- a deterioration in water quality

Despite several studies examining cortisol and other stress indicators, there is currently little evidence that rainbow trout do suffer from a prolonged crowding stress. Similarly, due to the practical difficulties of observing fish at high densities, there is a lack of verification that aggressive behaviour increases with increasing density. There is, therefore, little support for the two most commonly assumed causes of density effects. A third possible cause, non-aggressive physical obstruction, that reduces the ability of fish to see and access food, has also been suggested, but is as yet unproven, although reduced food intake with increasing density has been recorded (4, 15).

Several studies have used complex experimental designs in an attempt to discriminate between the effects of water quality deterioration and spatial limitation. These experiments have either maintained fish at different densities (kg/m^3) but with the same water quality (kg/l/min), or maintained the same density (kg/m^3) at different water qualities (kg/l/min). These studies have indicated that water quality deterioration was the major factor causing the depression of growth (4).

Summary

There is some evidence in the literature that increasing density can impact on trout welfare, causing increased mortality, fin erosion and reduced growth and condition. Nevertheless, for all the welfare indicators, whether density does have an effect differs between the studies, demonstrating the importance of study-specific factors. The difference between studies is illustrated by the wide range of resulting recommendations for maximum density, ranging from 4 to 260 kg/m^3 (4). Various factors - such as fish size, temperature, water exchange and aeration/oxygenation – have differed between the studies and are thought to account for these differences. Stocking density is therefore an important factor for fish welfare, but cannot be considered in isolation from other environmental factors. Due to the importance of environmental factors, it follows that the setting of a single maximum density limit would be inappropriate.

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ASSESSING THE EFFECTS OF STOCKING DENSITY ON THE WELFARE OF FARMED RAINBOW TROUT

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

Introduction

The welfare of farmed fish is a subject of growing public, commercial and governmental concern (1-5). The Farm Animal Welfare Council's report on the welfare of farmed fish (4) suggested that stocking densities used in commercial fish production are a welfare concern, and similar concerns have also been expressed by the pressure group Compassion in World Farming (1, 2). Unlike terrestrial farm animals where minimum spatial areas are stipulated to provide for an animal's behavioural needs (6), there are currently no regulations regarding the densities at which fish can be farmed. This report summarises the findings of two experiments that investigated the effects of varying stocking density and loading rates on the welfare of rainbow trout. Both experiments were carried out at the Institute of Aquaculture's Niall Bromage Freshwater Research Facility, as part of a project funded by the Department for Environment, Fisheries and Rural Affairs (Defra) and the British Trout Association (BTA).

What is welfare?

There is no universally accepted definition for welfare, although welfare is commonly seen to represent an assortment of notions relating to health, well-being and quality of life i.e. the physical and mental state of an animal in relation to its environment (7, 8). In light of the difficulties associated with a concise definition covering all aspects of welfare, an alternative approach has been to define what welfare is not i.e. lay down the conditions that must be met to ensure acceptable welfare. One such approach is the 'Five Freedoms' (Table 1), which is now one of the most widely accepted frameworks for animal welfare policy (7, 9). The Five Freedoms were originally developed with terrestrial animals in mind and some of the points are not relevant to fish welfare e.g. freedom from thirst. However, the principals of the Five Freedoms are recognised to be equally applicable to fish (5, 9, 11, 12).

Table 1. The Five freedoms of Welfare (10)

	Welfare Freedom
1.	Freedom from thirst, hunger and malnutrition
2.	Freedom from discomfort
3.	Freedom from pain, injury and disease
4.	Freedom to express most normal behaviour
5.	Freedom from fear and distress

How can fish welfare be assessed?

Assessing animal welfare is inherently complex and is hindered by subjective interpretations of an animal's feelings. Welfare assessment of fish is further complicated due to a lack of vocalisations and difficulties associated with observing behavioural patterns underwater. There is, however, a general consensus that welfare assessment should incorporate indicators that represent different aspects of welfare infringement e.g. stress physiology, health and behaviour (5). The approach taken in these experiments was to assess welfare through a range of morphometric measurements (growth, body and fin condition), and physiological indicators of stress (haematocrit, plasma cortisol and glucose) and immune response (lysozyme activity).

Experiment 1: The effects of stocking density on the welfare of rainbow trout

Rainbow trout (180 g ± 35 g, mean ± SD) were stocked in triplicate in 2 m diameter circular tanks (1.8 m^3) at densities of 10, 40 and 80 kg m^{-3}. Flow rates were set to 60 l min^{-1} giving biomass loading densities of 0.17, 0.67 and 1.33 kg l^{-1} min^{-1}. The fish were fed according to manufacturer's tables for 9 months. Dissolved oxygen levels were monitored using an Oxyguard™ system and maintained above 6.0 mg l^{-1} at all times. Each month, 60 fish per tank were sampled for weight, length and fin condition and 10 fish were blood sampled. The average weight obtained at each sample point coupled with fish numbers, allowed an accurate estimation of biomass in each tank. Fish were removed to maintain the tanks at the desired stocking densities throughout the trial (Figure 1).

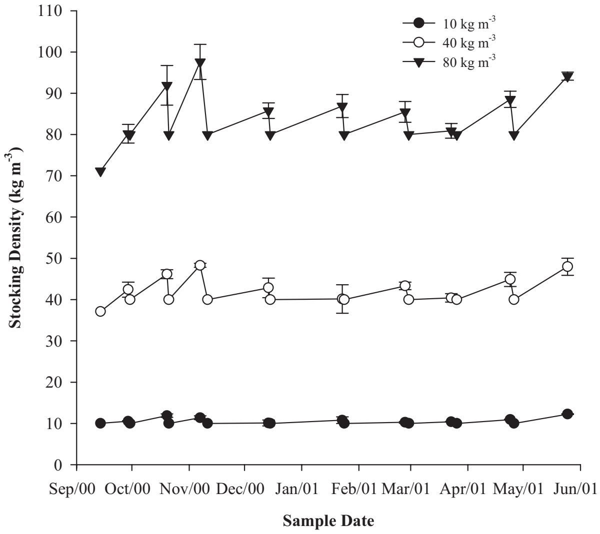

Figure 1. Biomass regulation in tanks of rainbow trout grown at different stocking densities; mean ± SEM of 3 replicates

Mortality was low in all treatments (2.3% at 20 kg m^{-3} vs. 1.3 and 1.4% at 40 and 80 kg m^{-3} respectively) and there was no significant treatment effect on growth (Figure 2).

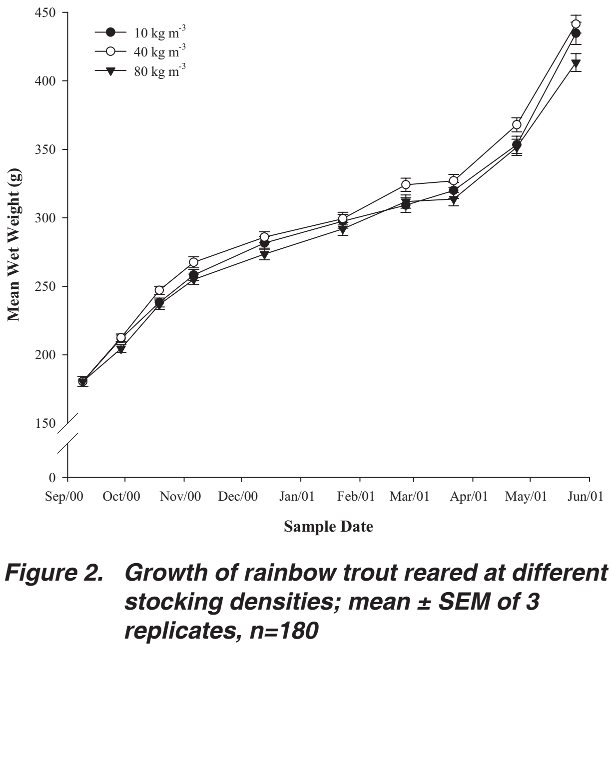

Figure 2. Growth of rainbow trout reared at different stocking densities; mean ± SEM of 3 replicates, n=180

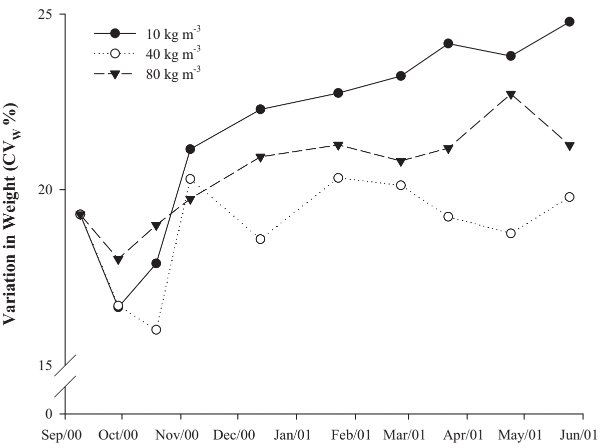

Figure 3. Measure of size variation of rainbow trout reared at different stocking densities

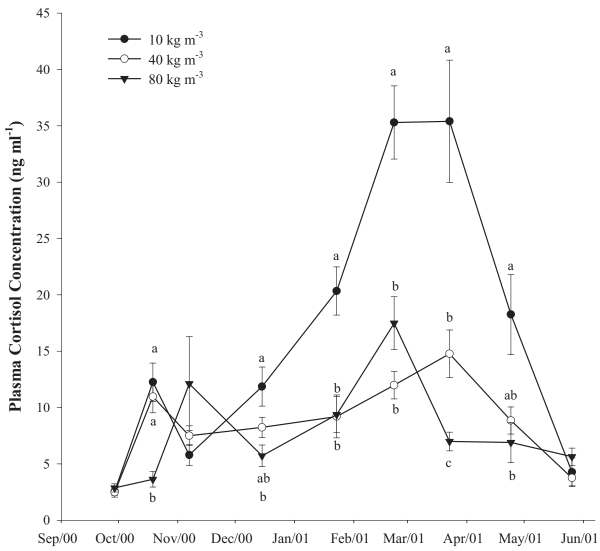

Figure 4. Plasma cortisol in rainbow trout reared at different stocking densities; mean ± SEM of 3 replicates per treatment (10 fish per replicate); different letters for each column denote significant differences (P<0.05)

There was, however, an indication that size variation was greater in the 10 kg m^{-3}, possibly indicating the presence of a stronger dominance hierarchy (Figure 3).

Occasional significant differences in condition factor were observed between the treatments, with lower condition in the 10 kg m^{-3} than the 40 kg m^{-3} treatment in February. However, at the end of the experiment there was no difference in condition factor between the density treatments.

There was evidence to suggest a cumulative effect of stocking density on fin erosion [expressed as relative fin index (RFL): fin length/total length x 100], with the 40 and 80 kg m^{-3} treatments having significantly lower RFL than the 10 kg m^{-3} treatment for all measured fins. There also appeared to be a confounding effect of water current direction, with the RFL of the left sided fins pectoral fins significantly smaller than the right sided fins in the 40 and 80 kg m^{-3} treatments. The water current was set in a clockwise direction and as the fish generally swam anticlockwise into the current, the left sided fin corresponded to the inside fin.

The results for haematocrit (red blood cell volume) and lysozyme activity (an element of the immune system) were more difficult to interpret as large fluctuations were related to changes in water temperature. However levels of cortisol (stress hormone) in the plasma were significantly higher in the 10 kg m^{-3} group on 5 of the 9 monthly sample points (Figure 4).

Experiment 2: The effects of water quality deterioration on the welfare of rainbow trout

The second experiment assessed the effect of water quality deterioration on trout welfare by adjusting inflow rates (20, 40, 60 l min^{-1}) in tanks containing the same numbers of fish. At the start of the experiment stocking density was 16 kg m^{-3} in all treatments, but the different flow rates resulted in loading rates of 1.3, 0.7 and 0.5 kg l^{-1} min^{-1} for the 20, 40 and 60 l min^{-1} treatments respectively. The only regulation of stocking density in this experiment was through the removal of 10 fish from each tank during the monthly sampling, so that stocking density increased through the trial as the fish grew. At the end of the experiment stocking density was 40.7, 41.1 and 45.6 kg m^{-3} in the 20, 40 and 60 l min^{-1} treatments, which equated to loading rates of 2.1, 1.1 and 0.8 kg l^{-1} min^{-1}.

Dissolved oxygen (DO) was monitored and maintained above 5 mg l^{-1} at all times. Oxygenation was required to maintain DO above 5 mg l^{-1} in the lowest flow treatment from the second month of the experiment. All of the treatments required oxygenation during the summer months when water temperatures peaked (≈14°C).

There were marked differences in levels of ammonia between the treatments, but un-ionised ammonia (NH_3) remained below 0.02 mg l^{-1}, which is the recommended 'safe' limit of for salmonid culture (13) at all times when ammonia was measured. There was a significant effect of inflow rate on growth, with the average fish weight significantly higher in the 60 l min^{-1} compared with the 20 and 40 l min^{-1} treatments from August until the end of the experiment (Figure 5).

There was also a significant effect of inflow rate on condition factor, with significantly higher condition factor observed in the 60 l min^{-1} compared with the

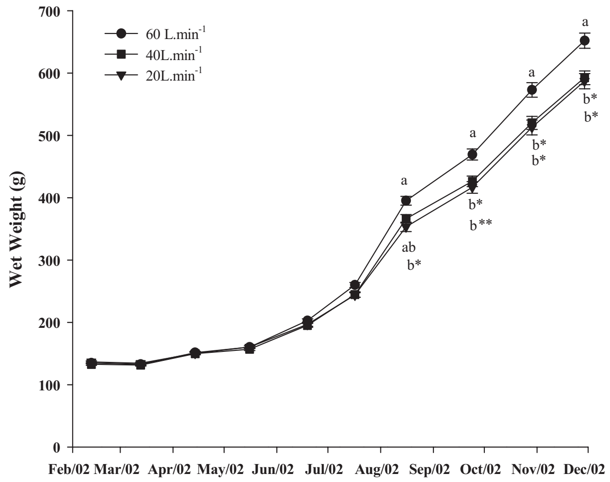

Figure 5. Weight gain of rainbow trout cultured in tanks with different inflow rates. Each point represents the mean (± SEM) Treatments not sharing a common letter are significantly different at that time point (*P<0.05, **P<0.01)

20 l min^{-1} treatment in August, and with the 40 l min^{-1} treatment in September.

Two mass mortality events occurred in the 20 l min^{-1} treatments due to plumbing failures, one of which resulted in the loss of one of the replicates. However, apart from these episodic events, mortality was low (<1%) in all treatments. There were no treatment related differences in fin condition or any of the other welfare indicators (haematocrit, cortisol, and lysozyme) in this experiment.

Conclusions

These trials highlighted some of the complexities of welfare assessment. The increased occurrence of fin damage with increasing stocking density in Experiment 1 suggested that higher stocking densities increased the injury to fins. However, the elevated cortisol, increased size variation and lower condition factor observed in the lowest density treatment suggested other aspects of welfare were poorer at lower stocking densities, possibly as a result of a dominance hierarchy. This preliminary study demonstrated that the relationship between stocking density and welfare is complex, and that presumed low as well as high densities may infringe possible aspects of trout welfare. Experiment 1 also highlighted the difficulties associated with attempting to prioritise welfare infringement e.g. what was the greater welfare insult, increased fin damage at the high stocking density, or the increased levels of cortisol and possibility of subordinate fish at the low stocking density?

The exact cause of the increased fin damage at higher SD remains unknown, although possible causes include abrasion against tank surfaces as a result of fish occupying suboptimal positions within the tanks, accidental damage caused at feeding and/or aggressive nipping of fins by con-specifics. Further work is required to identify links between increased stocking density and fin erosion and also to establish the implications of fin damage to fish welfare.

Experiment 2 demonstrated the potential for water quality deterioration to result in reduced growth of rainbow trout. The reduced growth and condition factor observed in the 20 and 40 l min^{-1} treatments was not accompanied by changes in any of the other indicators that were used to assess fish welfare. This suggested that these welfare indicators were either not sensitive indicators to water quality deterioration, or that the deterioration in water quality was insufficient to elicit an effect. Further work is required to identify critical limits of key water quality parameters for trout culture (carbon dioxide, dissolved oxygen and ammonia) and also to develop sensitive welfare indicators for water quality deterioration.

The two mass mortality events that occurred in the 20 l min^{-1} treatment were both the result of plumbing failures. It may have been a chance occurrence that both mortality events occurred in the treatment with the lowest flow (highest loading rate). However, lower flow rates do provide a smaller margin of error, and there are similar reports in the literature of such events in tanks with high loading rates (14).

In summary, these experiments demonstrated that provided good water quality is maintained, it was possible to grow rainbow trout at densities of up to 80 kg m^{-3} without affecting growth or mortality. However, operating at high stocking densities and loading rates may run an increased risk of mass mortality in the event of system failure. We reiterate the warning of previous authors regarding the need for increased supervision and the requirement of appropriate back-up systems when operating at high stocking densities or loading rates (15).

Acknowledgements

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PROGRESS ON PROLIFERATIVE KIDNEY DISEASE (PKD) RESEARCH

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A previous *Trout News* article (1) provided an introduction to the 'PKD Programme' of research commissioned by Defra with support from the BTA. Three projects based at the Universities of Aberdeen/ Reading and Stirling (Institute of Aquaculture) and at the CEFAS Weymouth Laboratory were set up to investigate various aspects of the disease in farmed and wild fish stocks. Additional NERC-funded studies led by Dr Beth Okamura at the University of Reading have targeted the ecology of the bryozoan (intermediate) hosts and parasite development within those hosts. A project board was established in order to:

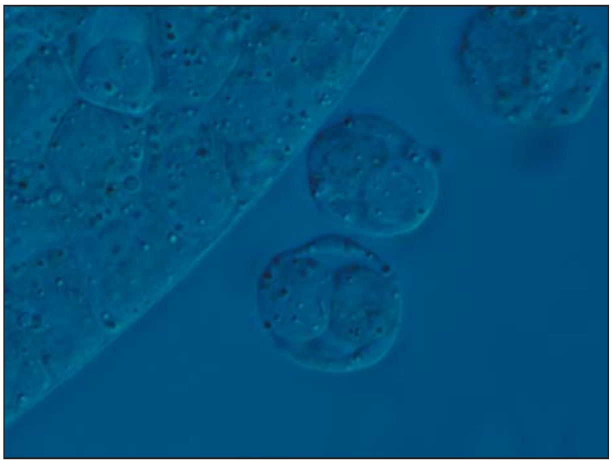
- Enhance collaboration and communication between research groups.
- Co-ordinate activities.
- Provide additional project monitoring and regular updates to Defra, the BTA and other interested parties.
- Establish training as required.
- Facilitate dissemination of research findings to a wider audience.

This article provides an update on the research within these projects and looks forward to the potential for controlling this important disease.

At the last PKD programme meeting held at the Institute of Aquaculture, University of Stirling, Oliver Robinson and Jane Davis, representing the BTA stressed the importance of the disease as a major limiting factor for trout production in the UK with estimated losses to the industry of approximately £2.5M per annum. Indeed, there is some evidence that the impact of the disease is worsening. Outbreaks are being reported in farms with no previous history of the disease and in addition, there are also increasing numbers of reports of the disease affecting salmon.

The main objectives of the project at Stirling have been to develop a bryozoan culture system, to examine the effect of fish mucus on spores, to purify parasite (*Tetracapsuloides bryosalmonae*) stages from the fish host and develop an *in-vitro* culture, to examine the antibody response to infection in infected fish and to produce monoclonal antibodies to the parasite. An *in-vivo* culture system has been developed for some species of bryozoans but it appears that food availability limits the extent of such culturing. It has been found that *T. bryosalmonae* infections are deleterious to bryozoan (*Fredericella sultana*) colonies maintained in culture. However, as long as the cultured colonies are treated carefully and plenty of food is available, they can survive. These colonies have

Feeding zooids on branch of a bryozoan (Fredericella sultana) colony



Tetracapsuloides bryosalmonae spore next to a sac containing other parasite stages

successfully been used to infect fish. Primary cultures have also been developed for the stage of the parasite that develops in the fish kidney allowing it to be grown under laboratory conditions.

Research at Stirling has also demonstrated that individual fish produce different antibody responses to the parasite with a wide range of antibodies being produced. It is believed that many of these are immunologically irrelevant, with the parasite producing an antigenic smokescreen, essentially diluting the effectiveness of the immune response against it. However, one of these antibodies, B4, has been shown to delay the onset of PKD when injected into fish and may therefore have an important role in the host response to the parasite and in the subsequent development of the disease. Interestingly, it is also present in the bryozoan stage of the parasite's development.

Research in Aberdeen has focused on the examination of a large group of immune messenger molecules called chemokines. These molecules control the recruitment of specific subsets of immune cells to inflammatory sites and are currently the focus of drug development with respect to the control of chronic inflammatory disease in humans. It has been found that certain chemokines are profoundly influenced by PKD infection in rainbow trout, highlighting the need for future chemokine research in fish with the aim of controlling the chronic inflammatory condition associated with this disease.

As with the infected fish host, state-of-the-art molecular techniques have also been employed at Aberdeen in the discovery of novel parasite genes in infected bryozoans. Such genes could be used as therapeutic targets in the prevention of the disease in the fish host. Infected bryozoans have been used to construct a gene library potentially enriched with parasite genes. So far, this library has been shown to be highly enriched with a *T. bryosalmonae* antigen gene originally sequenced from infected fish kidney, which clearly paves the way towards the discovery of other novel parasite genes. 290 gene clones from this library are currently being sequenced.

Work at the University of Reading co-funded by Defra and NERC has centred on two specific remits and has further focused on: assessing the ecology and development of *T. bryosalmonae* in bryozoan field populations; the effects of parasites on bryozoan hosts; the transmission of parasitic stages that develop in bryozoans and fish; and the geographical origin and transfer of the PKD agent by fisheries activities. Specific Defra remits entailed collection of bryozoan stages of the parasite for immune studies at the University of Aberdeen and optimisation of parasite culturing. The latter has identified that a combination of field-collection followed by laboratory culture in large recirculating aquarium tank systems provides the best means of maintaining thriving populations of bryozoans capable of supporting infections persisting for weeks to months. These mini-ecosystems represent a minimally labour-intensive method for maintaining long term and vigorous bryozoan and parasite growth and development. Further work has shown that the prevalence of parasitism in field bryozoan populations varies seasonally and that *T. bryosalmonae* can persist as cryptic stages for weeks to months in bryozoan hosts prior to proliferating as mature infective stages. The effects of parasitism on bryozoan hosts are variable with little effect during certain periods of year but rapid degeneration of hosts at other times. Transmission studies have not shown infection from bryozoan to bryozoan nor from fish to bryozoan, suggesting that the life cycle is still not fully resolved. Study of the genetic relatedness of the PKD agent from Europe and North America indicates that the parasite has not been moved around Europe through the movement of aquaculture species. This finding provides further supporting evidence that salmonids are a dead end host.

At CEFAS Weymouth, studies are being funded to try to understand the early progression of the disease and the differential susceptibility of numerous salmonids. Data shows that the parasite is able to rapidly locate and infect the fish. The parasite invades the host through the mucous cells in the skin and gills, before moving through the body via the blood system. Differences in host susceptibility appear to be related to a number of blood parameters, as well as the immune response of the fish.

Regular contact is maintained with all members of the group allowing useful discussions and collaboration and since 1992, almost 100 scientific papers and presentations have been completed ensuring that the wider scientific community is made aware of the advances that have been made in this important disease.

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THE FISH HEALTH RESEARCH PROGRAMME REVIEW, CEFAS WEYMOUTH, 28-29 APRIL 2004

Neil Auchterlonie, Defra, Science Directorate, Cromwell House, Dean Stanley Street, London, SW1P 3JH

CEFAS Weymouth hosted the 2004 Fish Health Review. The purpose of the review was to assess the quality and relevance of Defra-funded research in fish health and provide scientific direction for future research. Richard Cowan (Fish II) and David Mullin (Fish IIA) represented the Defra policy customer, and the research was assessed by an international (Germany, US, UK) team of external evaluators. In addition other policy, scientific, and producer representatives were present.

Day One, 28th April 2004

The evaluators and delegates were welcomed by Richard Cowan, Dr John Lock (Fisheries Science Unit, Defra), Prof Barry Hill and Dr Stephen Irving (both CEFAS Weymouth), who provided a background to the review and a description of the changes in fish health legislation. Some of the key points arising from these introductory presentations were the need to prioritise research topics in the face of declining funds and the development of contingency plans to counter exotic disease outbreaks. Following this introductory session, the research presentations were grouped into sessions by topic area.

Session 1: EPIDEMIOLOGY
(Chair – Dr Ron Stagg – FRS Marine Laboratory)

Project FC1137 – The characterisation and pathogenesis of parasites and diseases in fish and shellfish stocks.
Project leader - Steve Feist (CEFAS – Weymouth)

Steve Feist presented the report on FC1137, outlining the primary aim as the protection of wild fish and shellfish stocks through understanding the significance of disease, rapid diagnosis and determination of mechanisms of spread, life cycles and pathogenesis. Describing progress in the project, Dr Feist divided the descriptions of pathogens into those found in non-native species, native shellfish, and native wild fish. The research into parasites of imported coldwater ornamentals had shown limited parasites of concern, the theory being that ectoparasites are removed by treatments prior to shipping. Research on pathogenic parasites of native wild cyprinid populations was driven by concerns over perceived declines in wild fish populations and associated reports of heavily diseased fish fry. In a survey of three rivers, chub and roach populations showed a correlation between years of low recruitment and a high prevalence of parasites, indicating that disease may have a stronger influence on population success than temperature or flow rate. Dr Feist also described the management of the Registry of Aquatic Pathology (RAP) which currently holds over 800 specimens in the database. With CEFAS Weymouth as the OIE reference laboratory, there have been requests from other countries to provide material from the RAP for SVC and scallop pathology.

Project FC1150 – Improving understanding of the epidemiology and risks of serious fish diseases.
Project leader - Sophie St. Hilaire (CEFAS Weymouth)

Sophie St. Hilaire described how project FC1150 aims to gain a better understanding of the epidemiology of diseases that affect wild freshwater populations of fish in England and Wales, with a key purpose to underpin fish health policy. Working closely with the Fish Health

Inspectorate (FHI) and the Environment Agency (EA), the project provides notification of introduced and emerging disease causing acute mortality in carp, farmed trout and wild salmonids. The project also aims to design a system to review emerging fish and shellfish diseases around the world as an early warning system for Defra to identify threats to fish populations in England and Wales. The applied field research component of the project has concentrated on Proliferative Kidney Disease (PKD) in salmonids, a parasitic problem in chub (*Myxobolus buckei*), and koi herpesvirus in common carp.

Project FC1146 – An investigation into the prevalence and interaction of BKD in wild and farmed fish in selected river systems in the UK. Final Report. Project leader - Edel Chambers (CEFAS Weymouth)

Edel Chambers presented the report on FC1146 on behalf of the joint contractors CEFAS and the University of Plymouth. The policy drivers for this research are based on disease control legislation. The main objectives of the project were to: validate a PCR protocol to identify *Renibacterium salmoninarum* (*R.s.*- the causative agent of BKD) and determine the prevalence of *R.s.* in wild fish, farmed fish and environmental samples (water and sediment). Wild fish species sampled included brown trout, rainbow trout, grayling, salmon, pike and eel. In the sampling programme 946 salmonids and 45 eels were sampled, and clinical signs were seen in only 2 fish (1 salmon, 1 grayling), thus there is no evidence that endemic BKD is causing high levels of mortality. This was the first report of *R.s.* in eels. There was an apparent association between *R.s.* positive fish farms and *R.s.* prevalence in wild grayling. The PCR method was adapted to detect *R.s.* in river water, but the environmental sampling was hampered by insufficient resources and by the fact that there were no longer any *R.s.* positive fish farms. Ms Chambers then commented that there were still no control measures, apart from prevention and the maintenance of freedom from disease, accepted for use in the UK. The conclusion from this project was that *R.s.* is not causing clinical disease at the present time in England and Wales, but because of the nature of the disease and the lack of control measures we should not become complacent.

CARD programme – A Summary of the relevant research. Mark James (Fisheries Resource Management Ltd.)

Within Session 1, Mark James described the Committee for Aquaculture Research and Development and provided an overview of the complex picture of aquaculture R&D funding in the UK. Both devolution and the EU have had a considerable impact on aquaculture R&D funding, and in the face of these changes, the importance of co-ordination and effective partnership was emphasised. As a comparison to the domestic situation, Dr James described the strategic view of the Norwegian Research Council which has made a decision to invest £5m/yr over a 10 year period. Such a strategic R&D focus should back research topics that are likely to benefit the commercial sector. In conclusion, the UK has a broad portfolio of aquaculture R&D but one which is largely driven by the management and control of disease, environmental impacts and consumer safety. Much of the research is funded through government departments and therefore policy driven. Only 2% of the total of all R&D expenditure is derived from industry, charitable or regional enterprise funds. Mark James noted that the UK has a very strong aquaculture research base and it is an important economic sector in its own right. The CARD and Link programmes have emphasised the importance for engaging the industry with the scientific community, and the need for co-ordination amongst a broad range of sponsors with disparate interests.

Session 2: HUSBANDRY/WELFARE (Chair – Dr Mark James, FRM Ltd)

Projects FC0916 – Endocrinological and behavioural measures of the welfare of farmed fish in relation to stocking densities, and AW1203 - The effect of stocking density on the welfare of farmed rainbow trout. Project leaders - Tim Ellis (CEFAS Weymouth) and Jimmy Turnbull (Institute of Aquaculture, University of Stirling)

Tim Ellis introduced both projects, providing the background and policy relevance to the research by citing the Farm Animal Welfare Council (FAWC) report on the *Welfare of Farmed Fish* (1996). Dr Ellis provided a general description of welfare and the aims of the two complementary projects: to develop methods to assess welfare in farmed trout, and determine the effects of density on welfare through experiments and field sampling. Dr Ellis described the development and application of a non-invasive technique for the quantification of stress in fish, outlining the advantages over the historically used blood/cortisol measurements. A literature review on the effects of stocking density on rainbow trout had indicated that there is little evidence for stress due to crowding, and effects on growth appear to be due to water quality needs rather than spatial needs. Also a single maximum stocking density is of little relevance due to the importance of environmental factors. A suite of welfare indicators (mortality, growth, size variation, condition indices (body, liver, fins, gill, spleen), red blood cells, white blood cells, plasma cortisol, water cortisol (time series), plasma lysozyme, plasma glucose) had been used to assess fish welfare in experiments and the field. Experimental work has shown that for most of these indicators there is no effect of density, neither is there evidence for an adverse effect of increasing density on mortality nor evidence of a cortisol stress response. However, fin erosion was shown to increase with increasing density, most likely due to a combination of spatial and behavioural factors.

Jimmy Turnbull presented the results of a questionnaire sent out to industry. The main findings were that farmers use dissolved oxygen levels to assure fish welfare and that there is no current alternative to kg/m^3 as a unit for quantifying stocking density, even though constraints are recognised. He then described the development of a multivariate Welfare Index. This has proved a useful method for combining the individual welfare indicators, but it can be further improved. Dr Turnbull concluded by describing the continuation of the welfare programme through the projects AW1204 (Fin erosion and epidemiology) and AW1205 (Water quality and welfare indicators).

Project FC1144 - The use of prebiotics to improve fish health – Final Report.
Project leader - Michelle Stone (CEFAS Weymouth)

Michelle Stone introduced the project by describing prebiotics as "nutrients added to feed that can selectively stimulate already present and established populations of bacteria in the intestine, which are known to have a beneficial effect on the host". The relevance of this work to policy is through the potential reduction in the sustained use of chemotherapeutants. The main objectives of the project were to identify the microflora in the lower intestine of rainbow trout, investigate a range of prebiotic candidates for any effect on the bacterial populations, and study their effect on pathogen-challenged fish.

Using conventional and molecular biology techniques a range of bacterial species had been identified with *Serratia fonticola* isolated in high numbers from feral trout. No micro-organisms were isolated from farmed trout. Ultimately, two potential prebiotic candidates were tested *in vivo* after *in vitro* trials showed that these two compounds increased the growth rate of certain bacterial species. When incorporated into feed, one of these compounds increased the growth of certain intestinal bacteria – the dominant bacterial groups being *Aeromonas sobria* and *Clostridium gasigenes.* Using a *Y. ruckeri* cohabitation challenge, a group of fish fed a diet supplemented with one of the compounds showed a slight delay in the onset of mortality, suggesting that it has potential to improve survival in farmed trout exposed to pathogens.

Session 3: ENVIRONMENTAL IMPACTS
(Chair – Mark James, FRM Ltd)

Project FC1139 - Improving the health of fish by promoting natural disease resistance- a molecular biology approach.
Project leader - Stephen Baynes (CEFAS Weymouth)

Stephen Baynes described the objectives and policy relevance of increasing the health of stock whilst decreasing the environmental impact by reducing the numbers of disease treatments. CEFAS had a VHS challenge model with which to work, and this model was used to challenge three stocks of fish of known parentage provided by 1) Stirling University, 2) CEH Windermere (high and low cortisol responders), and 3) a Dorset fish farm.

In response to the VHS challenge, individual tanks of Stirling stock showed a variation in mortality rate from 5% to 35%. There were differences within the Windermere fish with c.100% mortality in the high cortisol responders versus a lower cumulative mortality (< 60%) in the low cortisol responders. The Dorset fish showed a family dependent mortality rate of between 8% and 60%. Dr Baynes summarised by stating that selection for cortisol response in the CEH Windermere fish had led to the extreme differences in response to the VHS challenge, and out-bred strains (Dorset stock) show a wide variation in resistance.

Project FC1125 - Factors affecting the disease susceptibility of fish.
Project leader - Myriam Algoet (CEFAS Weymouth)

Myriam Algoet introduced project FC1125 stating the policy relevance as providing advice on fish health and reducing the impacts of fish disease and the industry's reliance on chemotherapeutants. The objectives of this wide ranging project were the development of disease models for rainbow trout relevant to the UK situation and assessment of the roles of nutrition, acute stress, chronic stress, and genetics in disease susceptibility. Within the project, CEFAS had successfully developed challenge models for rainbow trout to RTFS, ERM, Furunculosis, IPN, *Saprolegnia* and *Vibriosis.* Additionally, acute and chronic stress models representative of the UK husbandry practices had been developed.

Ms Algoet then described the results on nutrition, reporting that neither feed deprivation nor overfeeding was found to affect susceptibility to RTFS or IPN. However, a slight reduction in fishmeal content (48% protein diet, compared with 56% and 63%) did have a significant impact on the ability to combat *Y. ruckeri.*

Investigations into the effect of immunostimulants on disease failed to demonstrate the level of protection claimed by manufacturers, although an L-Carnitine supplemented diet was shown to provide protection against ERM. The experimental work found no link between RTFS and acute stress. The results from experimental work on the influence of genetics on disease had been inconclusive. Ms Algoet concluded that links between nutrition, stress, genetics and disease are complex.

Project FC0925 - Evaluation of the risks involved using gene therapy techniques.
Project leader - Stephen Baynes (CEFAS Weymouth)

Stephen Baynes introduced the project by stating that the research was commissioned in response to concerns over the environmental risks associated with gene therapy in aquaculture - concern that DNA constructs injected into tissues as part of a treatment may migrate to the gonads and be passed on to the next generation. Escape of treated fish could then conceivably contaminate wild stocks. The objectives for FC0925 were therefore the gathering of information on the risk of transfer of recombinant DNA to germ-line tissue following introduction into juvenile fish.

Dr Baynes described the progress within the project: green fluorescent protein (GFP) is being used as a reporter to locate the gene construct in the fish tissues; GFP expression had been detected *in vitro* and *in vivo* testing had started; factors limiting GFP expression were being evaluated - temperature and interference. Future work will assess the migration of injected DNA within the tissues in fish of varying age, and in the long-term, the environmental risks associated with bath and oral delivery routes for the DNA construct.

Session 4: OVERVIEW OF RESEARCH FUNDED BY OTHER SPONSORS
(Chair – Dr John Lock, Defra)

Ron Stagg (Fisheries Research Service, Aberdeen) described the SEERAD funded programme of research into fish health, on behalf of the FRS. The programme structure includes the FHI for Scotland as well as research. With a total spend of £2.4m, £2.1m is devoted to fish health and £0.3m to aquaculture research. The greatest proportion allocated to research on IPN (£531k), followed by work on control zones (£340k), new species (£252k), sea lice (£222k), new and emerging diseases (£166k) and waste (£44k). Dr Stagg also gave a brief overview of externally funded research projects undertaken at FRS including work on oral vaccine delivery, immunology, and *Gyrodactylus* resistance markers in salmon.

David Graham (VSD, DARD, Belfast) described the DARD research programme at the Fish Diseases Unit, Veterinary Sciences Division, Stormont, Belfast, which centres around the diagnosis, pathogenesis and epidemiology of salmonid alphaviruses. The Sleeping Disease Virus is similar to the Pancreas Disease Virus and the name Atypical Salmonid Alphaviruses has been proposed. Sleeping Disease (SD) has been observed in England and Scotland and Pancreas Disease (PD) is currently a dramatic and severe disease in Ireland (up to 50% mortality in S0.5 and S1 populations), and there are also performance related losses.

Guy Richards (BBSRC, Swindon) presented the BBSRC's approach to funding research in the area of fish health and aquaculture. The BBSRC have roughly a £5m commitment to fish research every year. Within the Animal Sciences committee, there are four areas of direct relevance to fish health and aquaculture: From genes to physiology; Control of infectious diseases; Animal welfare; From the neurone to behaviour.

Nigel Hewlett (EA Fish Disease Laboratory, Brampton) described the areas of fish health work covered by the Environment Agency. The EA have a statutory duty to maintain and develop fisheries, and sustainability is the main driver with fish health and disease being important elements. The EA is the authority which gives consent for the movements of fish under Section 30 of the Salmon and Freshwater Fisheries Act 1975. The EA is involved in up to 150 mortality incidents a year. The EA's R&D programme supports policy and the provision of advice on fish health matters and includes projects on: the pathology and impacts of category 2 parasites; Spring Carp Mortality Syndrome; *Argulus* in trout; *Ergasilus sieboldi* – probably originally a parasite of bream, now trout; *Bothriocephalus achielognathi* – a parasite of juvenile carp, and now increasingly found on Crucian carp; *Paraergasilus longidigitis* – 'nose flea' – lives in nasal cavity and possibly affects feeding and reproduction. The presentation concluded with a list of the drivers for the R&D programme, which are: the Agency's scientists and Area Officers; support for EA policy; fisheries management issues; industry & representative bodies; links to wider fisheries and environmental issues.

DAY TWO, 29th April 2004

Session 5: DISEASE
(Chair – Dr Rupert Lewis, Defra)

Session 5a: BACTERIA

Project FC1143 - Development of vaccines and strategy for their use to control ulcer disease in coldwater ornamental fish.
Project leader - Brian Austin (Heriot-Watt University)

Brian Austin presented the project. More than 300 fish had been examined in a survey, and in addition to ulceration, fish also demonstrated fin and jaw erosion, and generalised septicaemia. Bacteriological samples taken from below and beside any ulcers identified atypical *Aeromonas salmonicida* (the original topic of this research), *Yersinia ruckeri*, *Streptococcus* and other *Aeromonads*. 47 cultures were retained from the initial survey – these comprised 40 *A. salmonicida* and 7 *Aeromonas hydrophila*, the latter subsequently proving to be *Aeromonas bestiarum*. Maximum fish mortality occurred with a mix of *A. salmonicida* and *A. bestiarum*. The work promoted the suggestion that the term atypical when applied to *A. salmonicida* is meaningless.

The ultimate goal is control of the disease through vaccination, and Prof Austin described how formalin killed whole cells were more effective than commercial Furunculosis vaccines alone in providing protection against challenge. There has been much interest in this work from a vaccine company, and a vaccine is now a commercial reality. The study also concluded that probiotics confer some protection against Ulcer Disease and may be useful in developing a health management strategy. In conclusion, Prof Austin stated that *A. salmonicida* is involved with Ulcer Disease although the taxonomy is unresolved at present, and vaccination or probiotics are effective control measures.

Project FC1151 - Risks to Public health and the aquaculture industry associated with bacterial fish diseases and their treatment.
Project leader - Myriam Algoet (CEFAS, Weymouth)

Myriam Algoet described the objectives of the project as centring around awareness of emerging disease, capability to diagnose, assessment of the impact, maintenance of the culture collection and anti-microbial susceptibility testing. Ms Algoet described the pathogens of which the research group have become aware during the project:

- *Candidatus arthromitis* was recently discovered to be a problem in the winter months
- *Chryseobacterium* sp.- causative agent of Salmon Skin Syndrome
- *Lactococcus garviae* - first outbreak in 2001 and there is some concern over public health aspects.
- Fungal diseases have also become an increasing priority since Malachite Green has been lost as a treatment.

Following the research conducted within this project, techniques for the diagnosis of diseases caused by these pathogens are now available to the Fish Health Inspectorate, and over 2800 isolates have been registered in the Culture Collection.

Session 5b: VIRUS

Project FC1136 - Identification and impact of emerging and notifiable virus disease in farmed and wild fish and shellfish.
Project leader - Peter Dixon (CEFAS, Weymouth)

Peter Dixon described the objectives for this large flexible project, as an examination of new and emerging viral diseases as well as an investigation into methods for the diagnosis of VHSV, IHNV, cyprinid rhabdovirus, and OsHV. Two recent additional objectives (collaborations with FRS Aberdeen) were to conduct a survey for ISAV in wild fish, and to determine the effect of ensiling and composting on survival of fish pathogens.

In describing progress against the objective to determine the significance of VHSV and IHNV, Peter Dixon reported on challenges against tench, bream, rudd, dace, barbel, chub and perch. Much of the work on the impact of emerging pathogens has focused on KHV. The highly virulent nature of KHV isolates can cause up to 100% mortality in carp, with different populations being equally sensitive. Barbel, bream, roach, rudd, tench, chub, dace, goldfish and orfe are all refractory to KHV. As part of the ISAV survey in 2000-2001, 751 Atlantic salmon and 276 brown trout were sampled from 29 freshwater and 12 estuarine sites in England and Wales, and tests by virus isolation and RT-PCR all proved negative.

Project FC1152 - Studies on the pathogenicity, tissue tropism and transmission of VHS.
Project leader - David Stone (CEFAS, Weymouth)

David Stone introduced project FC1152 by stating the main objective as gaining a better understanding of the pathogenicity of VHSV through molecular studies, the policy driver being EU fish health legislation. Dr Stone also described the work included in a further objective, on the substantiation of the tentative grouping of fish vesiculoviruses, and the development of a PCR-based assay to discriminate between problematic and non-problematic viruses.

Dr Stone described the research conducted on VHSV to determine whether concerns over the increased virulence of marine isolates in freshwater cultured trout are justified. In describing the research on vesiculoviruses, he stated that four subgroups of the Group I (SVCV) viruses could be differentiated.
Dr Stone then described the experimental work on a Russian SVCV isolate (FB1/03) which produces

no mortality in i.p. injected yearling carp, but 70% mortality in i.p. injected rainbow trout fry. This may be the first example of a fish virus adapting to a new host, and as such could be a good model to demonstrate the risk that viruses in wild fish populations, such as the marine forms of VHSV, can adapt and become pathogenic for a new species.

Session 5c: PATHOLOGY/PARASITOLOGY

General Overview on the PKD programme of research.
Steve Feist (CEFAS, Weymouth)

Steve Feist introduced the suite of research projects on PKD by describing the global impact of the disease. PKD is a major constraint to trout production in the UK (approximately £2m losses per annum in the industry). The disease has been found in several European countries and also in USA and Canada. Bryozoa are now recognised as the source of the problem. Some evidence also points to PKD being associated with declines in wild salmonid populations in Switzerland. The PKD research group formed after a PKD workshop was held at CEFAS Weymouth. The Terms of Reference for the PKD programme include the provision of information to Defra, training, and the dissemination of information to a wider audience.

Project FC1138 - Life cycle and transmission requirements of the PKD organism and other myxosporean pathogens of freshwater fish.
Project leader - Matt Longshaw (CEFAS, Weymouth)

Matt Longshaw introduced the project by describing the main objectives which focus on understanding the lifecycle of the parasite, determining early pathogenesis, and identifying the species of Bryozoans harbouring *Tetracapsuloides*, the causative agent of PKD. The policy drivers are control of the disease and assessing the impact on wild fish populations.

Dr Longshaw described the research at PKD enzootic farms, which identified clear spatio-temporal trends (visible infections in April-May, but also in September) and inter-annual variation. The future requirement is to obtain a long term data set which would allow management and protection of farmed and wild stock through the identification of lifecycle patterns and mechanism of spread. Work on PKD infection trials has been conducted with rainbow trout, salmon and grayling. The route of entry of the parasite has been determined, and infection can take place in less than a minute, with spores viable for at least 20 minutes in the presence of a host. Research into pathogenesis of the disease has shown that the parasite enters through mucous cells, and there is a limited host response in the first few weeks.

Project FC1111 - The immunology of PKD in fish – Identification of protective antigens and host immunity.
Project leader - David Morris (Institute of Aquaculture, University of Stirling)

David Morris reported on FC1111. He started by illustrating that *in vivo* culture of *Tetracapsuloides bryosalmonae* within bryozoa is now possible, showing a video of the development of a *T. bryosalmonae* infection under light microscopy. Although *T. bryosalmonae* causes pathological changes in the bryozoan *Fredericella sultana* at higher temperatures (~18°C), by incubating bryozoa at lower temperatures (12°C) infection can be maintained with less obvious pathological effects. Polar capsule discharge was observed in spores exposed to fish mucus. The best results for *in vitro* culture of *T. bryosalmonae* from rainbow trout were obtained from explants of anterior kidney. The parasites appeared to replicate in culture, but fish cells soon overgrew the culture.

Dr Morris then discussed the immunology work. Western Blot analysis showed that there was variation in the response of individual fish to the parasite, and immunomagnetism was being used to purify antigens which are currently being analysed. An antigen has been identified that may be important in the pathogenesis of the disease. Future work will involve the examination of antigens for their potential as vaccines for PKD.

Project FC1112 - Immune gene expression during PKD infection.
Project leader - Chris Secombes (University of Aberdeen)

Chris Secombes opened his presentation with a description of the Scottish Fish Immunology Centre which was set up in June 2003, comprising research groups at Aberdeen University, FRS Marine Laboratory and the Institute of Aquaculture at Stirling University. He then went on to describe the fish immune response to *T. bryosalmonae* infection and the regulation of the inflammatory and immune responses. Prof Secombes argued that the host immune response may be indicative of the dysregulation of the immune system.

Prof Secombes described the work with naïve and previously exposed ('immune') fish and gene expression before and during parasite exposure. The process of Suppressive Subtractive Hybridisation (SSH) had been successful in facilitating the identification of trout genes up-regulated by PKD infection. The related work at Reading was also described where the SSH procedure has been applied to identify genes in infected bryozoans. Finally Prof Secombes described the relevance of the work in terms of controlling the disease, stating that the chemokine (regulators of the immune and inflammatory response) research provides the possibility of relieving the chronic inflammation associated with the disease and the discovery of novel parasite genes could be beneficial in vaccine development.

Project FC0929 – The genetics of PKD resistance in rainbow trout.
Project leader - Brendan McAndrew (Institute of Aquaculture, University of Stirling)

Brendan McAndrew described the background to this project, including the Link project TRT12 on the selective improvement of rainbow trout. FC0929 is a collaborative project between the Institute of Aquaculture, the British Trout Association and the Roslin Institute. The rationale for this work is that there has so far been no successful scientific attempt to assess quality and improve the genetic resource base of the UK rainbow trout industry. Recent developments in marker technology have offered more cost effective approaches to conduct this type of research. As the scientific work for this project has not yet started, Prof McAndrew described the approach to be taken and ended the presentation by listing the aims of the work: estimate susceptibility at the family level in four strains; identify and breed from families with high and low resistance; challenge these families and assess response; assess the impact of disease challenge on future breeding performance of fish; develop a breeding strategy.

Project FC1145 - Semi-automated recognition of fish pathogens using statistical classification.
Project leader - Andy Shinn (Institute of Aquaculture, University of Stirling)

Andy Shinn concluded the presentations with a brief description of the Gyrodactylids and the importance of *Gyrodactylus salaris* in particular. Gyrodactylids are one of the fastest known reproducing monogeneans, and we should be aware of the devastation which could be caused if this parasite were to be introduced into the UK due to the lack of a suitable method of control. Dr Shinn emphasised the importance of a means of rapid identification of the parasite in order that the spread could be minimised. Dr Shinn described the Institute of Aquaculture *Gyrodactylus* image database. The project focused on developing statistical methodology to discriminate *G. salaris* from the endemic British species of *Gyrodactylus*, based upon morphological features.

Session 6: SUMMARY OF REVIEW AND FUTURE REQUIREMENTS FOR RESEARCH (Chair – John Lock, Defra)

The review closed with an open discussion session led by the evaluators. Richard Cowan and Dr John Lock then thanked the evaluators, the presenters and the delegates for their participation and efforts in making the meeting such a success.

TRIPLOID TROUT IN NATIVE TROUT WATERS: PHASE 1 – LITERATURE REVIEW AND RECOMMENDATIONS FOR PHASE 2

The Environment Agency has developed a National Trout and Grayling Fisheries Strategy in which it sets out its approach to potential risks encountered when considering applications for Section 30 consent to introduce fish to inland waters. The Strategy recognises that, whilst stocking is crucial to the success of many trout fisheries, there are risks to wild stocks associated with stocking farmed trout. These may arise either because the trout population density is increased, thus creating competition or predation by stock fish and/or stimulating an influx of predators or higher fishing pressure, in both cases leading to higher mortality of wild stocks, or by introduction of disease or effecting a change in the genetic composition of wild stocks through interbreeding.

Phase 1 of this project has produced a literature review covering the scientific and technical advances and effectiveness of the processes used to produce sterile triploid trout and the biological characteristics of female triploid brown trout. This was combined with information obtained from interviews with other researchers, farmers currently producing triploid and diploid trout (both brown and rainbow) in the UK and others who have experience of the performance of triploids in fisheries.

The review concludes that there is no evidence that the release of all-female triploid brown trout would adversely affect the genetic integrity of natural stocks of brown trout. Though diploids appear to be more aggressive than triploid trout and compete better in farm conditions, stocked triploids (especially if they are larger than wild fish) will, nevertheless, compete with wild trout for limited food and habitat resources. From the anglers' point-of-view, the behaviour of triploid brown trout may be similar to 'normal' stock fish, though they will show better condition in winter and spring and their flesh quality is likely to be less variable seasonally. It is possible that they may show poorer performance at elevated temperatures but this is unlikely to be a significant disadvantage where they are normally stocked.

A review of commercial practices, to assess the feasibility of increasing production of triploid brown trout in England and Wales, was based on interviews with trout farmers. These revealed the techniques used to induce triploidy, including the effectiveness in terms of % triploid and survival at each life stage, together with any special husbandry requirements. Comments were also made about commercial viability in relation to diploid brown and/or triploid and diploid rainbow trout. (Large numbers of all-female triploid rainbow trout have been produced and used successfully for restocking for some years.)

The growth advantages associated with triploid trout begin to show after about 16-18 months when diploid fish begin to divert energy into gonad growth. The triploids continue to grow at the same rate and soon overtake the diploids, which never regain this differential.

It is reported that triploid fish are less robust than diploid fish and are more prone to stress, especially reduced oxygen. They require more careful handling, reduced stocking densities and first use of good quality water.

An evaluation of the potential for increases in triploid brown trout production in England and Wales (to meet potential demand under the Agency's Strategy in relation to 'native trout' waters) was based on information collected in the review of commercial practices and from a questionnaire survey of diploid brown trout and triploid rainbow trout producers. A risk analysis is presented of the technical, logistic and economic factors that may constrain more extensive adoption of triploid brown trout production, including demand, start-up costs, level of price premium for triploids compared with increased costs, lack of technical knowledge, concerns over fish health etc., and the potential of each site for producing and/or on-growing triploid brown trout. The likely level of uptake and thus production of triploids has been assessed under different scenarios, and recommendations are given to facilitate increased adoption of the technology of producing triploid brown trout.

There is considerable potential for increased triploid brown trout production by both current brown and rainbow trout producers in England and Wales, though this may be constrained by a lack of technical knowledge (which is not freely available). Dissemination of the method for triploid production would facilitate uptake of the technology, and more research is required to identify the water temperature and quality parameters required for triploid production. Advanced notice of changes in stocking policy, and a campaign to inform angling clubs and others about the benefits of stocking with triploids, would encourage diploid producers to adopt the technology needed to switch to triploid production and ensure market stability.

The final part of the report outlines the design of a programme of investigations to compare biological and fishery performance of diploid and all-female triploid brown trout stocked in rivers, and a means to evaluate objectively the risks of stocking with triploids. The field programme is based on population sampling in a range of fisheries and river types, where all-female triploid brown trout and diploid brown trout are stocked alongside wild trout, using marked or tagged batches of stocked fish, anglers' catch records and electro-fishing.

This project supports the Environment Agency's National Trout and Grayling Fisheries Strategy and its associated stocking policy. The outcome is intended to inform a review scheduled to take place in 2006 to assess whether further restrictions on the stocking of farm-bred diploid trout (exclusive of those bred from local wild brood stock) and their substitution by triploid brown trout are justified.

This R&D Technical Summary relates to information from R&D Project W2-078 reported in detail in the following output:-

R&D Technical Report W2-078/TR1
Triploid Trout in Native Trout Waters: Phase 1 – Literature Review and Recommendations for Phase 2
ISBN 1 844 32223 8 November 2003

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Website: www.eareports.com

FUTURE OF BROWN TROUT STOCKING: DIPLOIDS, TRIPLOIDS OR NONE?

Paul Knight, Director, Salmon and Trout Association, Fishmongers' Hall, London Bridge, London EC4R 94L

The Environment Agency's (EA) Trout and Grayling Strategy is receiving a controversial press now that the first of its policies are being implemented. One reason is that the EA have put a widespread designation of 'Native' trout water status on any river system with even the suspicion of a trout living within it. There have also been fears from fishery managers and anglers that stocking will no longer be permitted, or if allowed, only with triploid stock. Besides questions over the survival factor of triploid fish, especially in rain-fed river systems, they are not yet readily available in the numbers that would be required to replace diploids.

However, after meeting Dafydd Evans, Head of EA Fisheries, and Guy Mawle, EA Fisheries Strategist and principal author of the Strategy, and then re-reading the Strategy in light of their comments, I am somewhat less concerned about its delivery than I was. We were assured that stocking will still continue in line with practice over the last five years, and even higher levels will be considered, provided triploids make up the extra numbers. The EA also stressed that they had no intention of imposing future 'no stocking' regulations over 'Native' fisheries; indeed, Dafydd Evans highlighted the Strategy's implicit policy of maximising socio economic benefits from trout fishing, which would be inconsistent with a cutback in stocking consents.

Wild Fisheries Protection Zones will only be designated after close consultation with local fisheries interests and, whilst stocking will cease within these zones, it will still continue elsewhere on the system. Fisheries within the Protection Zones could still operate, and market themselves as 'wild'. It is not anticipated these areas of no stocking will be widespread.

The EA will take a long-term decision over the use of triploids in 2006. We expressed concerns that triploids were not ideal in the extremes of conditions experienced in rain-fed catchments, and the EA confirmed that further research was underway. If the research results favour the use of triploids in some areas as the stocking method of the future, then we will lobby to ensure there is adequate time for fish farmers to make a seamless transition and produce sufficient triploid stock to meet demand.

It was also agreed that the research carried out, both inside and outside the Agency, into the impact of stocked fish on wild fish should be co-ordinated and monitored over the next two years so that maximum acceptable (to EA) data was available in 2006 to make scientifically-informed decisions over the delivery of the Strategy; absolutely vital if it is to succeed. In light of this information, we support the EA's aim to help self-sustaining populations of trout to prosper, and to find the best way to use supportive stocking while still maximizing benefits for trout angling.

The Salmon and Trout Association (S&TA) Trust is raising funds to support a PhD research project on this critical issue. The S&TA Trust is working with the Game Conservancy Trust to finance a three year scientific examination into the impacts of stocked trout on wild fish. With the results from this research, decision making on this complex subject of stocking may then be guided for the first time through science conducted in the UK. Management guidelines can then identify best practice for the benefit of all fishery owners and trout fishermen.

In summary, the S&TA is now happier about the Strategy's delivery, with continued access to most trout fishing assured with the EA's commitment to continue to allow stocking. However, we will monitor the Environment Agency and press to ensure that research underpins policy, local consultation plays a major role in future trout management, and fish farmers are given adequate notice of any changes that will impact their business.

Further information

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ENFORCEMENT OF FISH HEALTH REGULATIONS

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Law enforcement takes many forms but in the United Kingdom policing is effected largely with the consent of the public. Experience over many years has proved the wisdom of this approach, which is particularly relevant to the enforcement of Fish Health Regulations. It is plainly in the interests of everyone involved in the trade that the health of our fish stocks should be protected against the many disease and environmental threats that face it. It is apparent, however, that the greatest single threat to the health and welfare of our fish is that posed by the activities of some people in the trade, perversely, among those who have the most to lose by its demise.

Although logic suggests there should be only one high standard of fish farming and fish welfare, sadly the diversity of the industry and the people in it inevitably renders this an unlikely prospect. For this reason CEFAS has adopted an enforcement approach which on the one hand offers advice and assistance to fish farmers whenever possible in order to avoid confusion and encourage best practice, whilst on the other hand seeks to identify and actively target those individuals whose activities represent the biggest threat to the health of our fish, both farmed and wild. The former approach is successful in the vast majority of cases and our increasingly close relations with many individuals and organisations bears testimony to this. Most people recognise the need for some form of regulation in order to create a consistent standard and quality of fish and fish welfare.

The detractors who dismiss out of hand any form of government involvement, who believe the industry can be self-regulated, are the group from which most offenders originate. Their greed and disregard of regulatory control is more than likely to lead them to committing offences under the regulations. This has been illustrated in recent years by those involved in illegally importing diseased live fish. Such offences pose a direct threat, not only in the context of spreading fish disease but also in the dramatic impact such disease outbreaks would have on the livelihoods of fish farmers, fishery owners, anglers and other ancillary trades people. Such individuals are unlikely ever to be capable of self-regulation, so we see it as our primary role to stop their illegal activities for the benefit of the industry as a whole.

Although the number of prosecutions (for a variety of offences) has risen in recent years it is still a very small number when compared to the sheer volume of fish-related activity that takes place across the country. This may be due in part to our limited resources, but it is also due to the growing number of anglers, the popular fishing press and people in the trade who now accept the need for constant vigilance when it comes to protecting our fish from disease. They are prepared to support us in our work. We will continue to do all we can, but we can do so much more with the active support and participation of all interested parties. Help us to rid the industry of those involved in spreading disease. Contact CEFAS with any information you may have.

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FISH HEALTH CONTROLS: THE ACTIVITIES OF THE FISH HEALTH INSPECTORATE IN ENGLAND AND WALES 2003

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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 2003, 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. All registered salmonid farms were visited in the spring, with all sites holding broodstock or operating hatcheries, receiving a second inspection during the autumn. Samples were taken from approximately half of these farms as part of 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.

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 21 such samples for notifiable diseases were taken in 2003 continuing the trend of low numbers seen in recent years, possibly reflecting a general improvement in fish health on trout farms. None of these investigations confirmed the presence of any notifiable disease.

The Inspectorate is also contracted by the Veterinary Medicines Directorate to collect samples of farmed fish for veterinary residue testing. A target of 106 samples from salmonid farms was achieved, with an additional 46 samples taken during follow-up investigations on two farms following the detection of residues of malachite green or leucomalachite green, and on one farm on suspicion of use of an unauthorised substance.

The inspection programme for coarse fish sites during 2003 involved a single visit to each farm site, to assess the health of the fish stocks, and to check movement,

Table 1. Number of tasks, by category, undertaken by the Fish Health Inspectorate in 2003

	Site type		
	Salmonid	Coarse	Total
Farm inspections (no samples)	238	168	406
Routine sampling and inspection	143	0	143
Inspection and sampling on suspicion	4	2	6
Notifiable disease re-tests and contact tests	4	8	12
Reported disease outbreaks & mortality investigations	17	170	187
Import checks: Sampling	14	82	96
Inspection/physical checks	4	39	43
Export certification	5	82	87
Farm registration visits	5	17	22
Site disinfection visits	1	0	1
Wild fish monitoring	6	0	6
Other visits/inspections	15	195	210
		Total	1,219

mortality and medicine records. In addition, the programme of import checks on consignments of SVC susceptible species coming from non-EU countries was maintained. As a result a total of 121 consignments were inspected, with 82 sampled, from all of the major countries supplying such fish. All tests proved negative for SVC.

The Inspectorate also investigated 170 mortality events in coarse fishery waters and in sites holding coldwater ornamental fish during the year. Two sites tested positive for SVC and were subject to Designated Area Orders for this disease. The increase in investigations of mortalities in coarse and ornamental fish was possibly associated with a significant increase in Koi Herpesvirus (KHV) infections, primarily in ornamental carp.

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 2003. One farm subject to statutory controls for BKD completed a three-year programme of six negative re-tests, and the Designated Area Order on the site was revoked. At the end of the year only 3 sites remained designated for the disease. None of these sites are currently operational farms, and it is hoped that measures can be taken in 2004 to demonstrate the absence of disease and so remove statutory controls. There are therefore no active sites designated for BKD in England and Wales.

IPN. All salmon farms continue to be tested annually for IPN, and in 2003 all sites tested negative in England and Wales. There are no farms subject to movement restrictions for this disease.

Gyrodactylosis. All salmonid samples from farms or wild environments were screened for *G. salaris* and none were found positive. As in previous years 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 one commercial coarse fishery, and one site comprising a coarse fishery and coarse fish farm in 2003. The disease outbreaks appeared not to be linked, and statutory controls were placed on both sites. Follow up investigations and contact testing failed to identify the source of the infections.

Re-testing for SVC took place on 3 infected sites in 2003, all tested negative for the disease. At the end of 2003 there were 8 sites designated for SVC in England and Wales.

Table 2. Imports and exports of fish monitored by the Inspectorate in 2003

A.	**Import licences by category for trade from non-EU countries**		
	Tropical species (annual licence)		180
	Koi & goldfish (annual licence)		122
	Specified purpose (Indiviual consignment)		137
	Human consumption		56
		Total	495
B.	**Movement documents for EU trade**		
	Import documents received/checked		
	Salmonid eggs		79
	Turbot (for direct consumption)		154
	SVC susceptible fish		91
	Other fish		159
	Shellfish		18
		Total	501
C.	**Export documents issued**		
	Fish		240
	Shellfish		86
		Total	326

Emerging diseases

Candidatus (Summer Enteritic Syndrome). Following reports of increased levels of mortality on a large table trout farm, examination of affected fish revealed severe enteritis, with oedema of the lower intestine and sloughing of the intestinal mucosa. Diagnostic investigations identified the presence of a non-culturable filamentous bacterium, Candidatus, in the digestive tract of the fish. This condition is prevalent in continental Europe where it is known as Summer Enteritic Syndrome. This is the first record of this disease in the UK. The potential impact of the spread of Candidatus in England and Wales is likely to be limited as the condition proved easily controlled by the increase in common salt concentration in the fish feed. However the appearance of this disease highlighted the need for farmers to be rigorous in monitoring levels of mortality, and in assessing the health of their stocks. In the case of this disease, prompt treatment can prove both effective and economical.

Strawberry disease. This condition is characterised by superficial raised red lesions on the flanks and ventral surfaces of the skin of rainbow trout. It appears not to debilitate affected fish but results in increased rejection rates by fish processors. Strawberry disease is temperature related occurring in late spring and summer, in a limited geographical area. Certain fish farms appear to be particularly badly affected by this condition. To date diagnostic tests have failed to identify an infective agent. Further work is planned on affected sites in 2004 to characterise the disease, and identify the cause of the condition.

Koi Herpesvirus (KHV). The emergence of Koi Herpesvirus (KHV) as a major cause of mortality in koi and other varieties of ornamental carp continued in 2003. Over 50% of the mortalities of koi investigated by the Inspectorate in 2003 were attributed to KHV. This increase in recorded incidence of KHV possibly reflects the improvement in the sensitivity of diagnostic tools developed for the identification of the disease, as well as the spread of KHV in ornamental carp populations. KHV proved a considerable challenge to the ornamental fish industry, with several large importers moving away from dealing in koi. In other instances quarantine facilities were developed with a view to expressing any disease prior to the fish being sold into the retail trade.

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 six disease investigations on coarse fisheries during the year, in each instance associated with significant mortalities. It was clear from a number of these sites that ornamental carp had recently been introduced into the fishery. This reinforces the view that the spread of KHV is linked to the rearing or holding of common carp for restocking along with ornamental varieties of carp, and to the deliberate stocking of fisheries with ornamental carp.

Import/export Trade

The demand for licences to import fish from countries outside the EU continued at a high level with a total of 495 licences issued. This figure represents a slight decrease over the previous year, and possibly reflects a decline in trade in coldwater ornamentals linked to the prevalence of KHV in imported fish. Table 2 gives details of the number and type of licences issued and also movement documents issued for fish exports, by fish type.

The major import trade remains that in tropical fish, goldfish and koi carp from outside the EU. Imports within the EU were predominantly salmonid eggs for farming and turbot for direct consumption, as in previous years. The export trade was again predominantly ornamental fish to the EU, with a few salmonid egg 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 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 2003, 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 coarse fishery waters reinforces the need to remain vigilant in our efforts towards the prevention of illegal fish imports with the emergence of KHV in wild common carp providing a timely reminder of the threat posed to our fish stocks by exotic diseases.

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.

COARSE/ORNAMENTAL ARTICLES

KOI HERPESVIRUS- A THREAT TO WILD CARP

Keith Way, CEFAS Weymouth Laboratory, Barrack Road, The Nothe, Weymouth, Dorset DT4 8UB, UK

Introduction

In 1998 a disease emerged that caused mass mortalities in populations of cultured common carp (*Cyprinus carpio carpio*) and koi carp (*Cyprinus carpio koi*). Devastating losses occurred on farms culturing carp in Israel and Germany and outbreaks of disease with a similar aetiology occurred in koi carp in the USA, England, Germany and the Netherlands. A herpesvirus was isolated from carp during many of these outbreaks that was later shown, in transmission studies, to be the cause of the disease and was given the name koi herpesvirus - KHV (1). In Israel both the common carp industry and ornamental carp exports have been affected by the disease with 90% of carp farms having experienced KHV disease outbreaks by the end of 2001 (2). A virus isolated from earlier outbreaks of disease in Israel had been referred to as carp nephritis and gill necrosis virus (CNGV) (3), but this has since been confirmed as KHV. More recently, Indonesia and Japan (2002-2003) have experienced extensive KHV disease outbreaks that have resulted in considerable financial losses to both their ornamental and food-carp industries. To date, 10 European countries have reported outbreaks of KHV disease and the great majority of these have affected koi carp populations at ornamental fish importers, wholesalers and in hobbyist's ponds. However, KHV disease has been reported in common carp farms in Germany and poses a serious threat to the extensive pond culture of food carp in East-European countries as well as wild carp populations all over Europe.

KHV in the UK

In the UK, KHV was first isolated in the year 2000 during a disease outbreak at an ornamental fish import and retail site in northern England. Outbreaks of clinical disease with signs similar to KHV disease had been reported in 1998 and 1999 (4) but techniques to confirm diagnosis did not become available to the CEFAS Weymouth Laboratory until 2000 (5). More KHV outbreaks were confirmed in each of the next 3 years using polymerase chain reaction (PCR) - and cell culture-based assays developed in the USA. Later, molecular-based detection methods were developed at CEFAS to analyse archive histological material for the presence of viral DNA or RNA. Using these methods, KHV DNA was detected in tissue samples taken in 1996 during an unexplained mass mortality of koi and common carp in the UK (6).

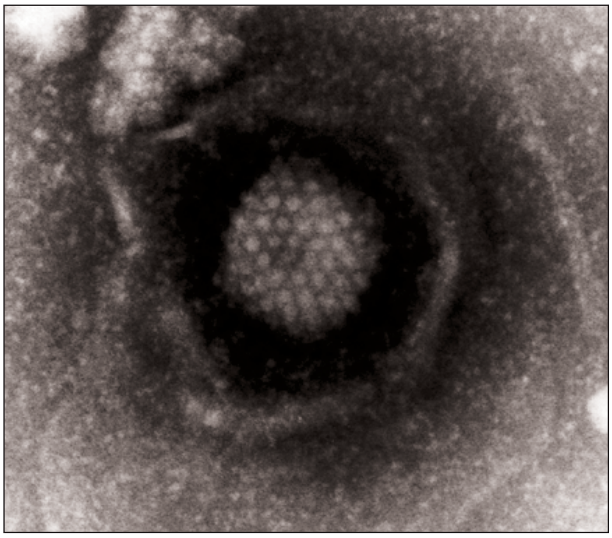

***Figure 1.** Electron micrograph of a koi herpesvirus particle*

Until 2003, KHV had only been detected and isolated from sites in the UK holding imported ornamental carp. However, between May and August 2003 CEFAS detected KHV in common carp, during investigations into large mortalities of carp in angling waters in England. It is suggested that such introductions of KHV are linked to the rearing or holding of common carp, destined for restocking fisheries, alongside ornamental varieties of carp and, in some cases, the stocking of waters with ornamental carp (7).

Herpesviruses

The word 'herpes' comes from the Greek to creep and these viruses are able to creep into undetectable places in some body tissues such as nervous tissue. The diseases are most commonly characterised as chronic and recurrent and often enter a latent state, re-appearing when the animal becomes stressed. Herpesviruses can be very difficult to detect if they become latent and in this state may infect an animal for the rest of its life. Human diseases caused by herpesviruses include cold sores, glandular fever, genital herpes, chicken pox and shingles. Herpesviruses are known to infect a wide range of other mammals as well as reptiles, birds and fish. Herpesvirus diseases are known from a number of other fish species including catfish, eels, goldfish, salmon and sturgeon. KHV has been shown to be genetically similar to the only other herpesvirus known in carp, the carp pox virus.

Susceptible fish species

The disease affects only carp of the species *Cyprinus carpio* and its varieties including common carp (*Cyprinus carpio carpio*), koi carp (*Cyprinus carpio koi*) and ghost carp (common x koi cross, *Cyprinus carpio goi*). Carp are often raised in polyculture systems with other ornamental or food fish species but no other commonly held fish species have been shown to be affected by the disease. Studies in Israel have shown that the disease is not transmitted from KHV-infected carp to goldfish (*Carassius auratus*) grass carp (*Ctenopharyngodon idella*), silver carp (*Hypophthalmichthys molitrix*) or tilapia (*Oreochromis niloticus*) (2).

KHV disease signs

The disease is highly infectious and occurs naturally at temperatures between 17°C and 26°C with an incubation period of 7-21 days depending on water temperature. Morbidity is often 100% with mortality up to 90% at higher temperatures.

Behavioural signs of disease include lethargy, erratic swimming and frequent ventilation (gasping). At high water temperatures fish can die within hours of the first signs appearing but at lower temperatures the course of the disease is more protracted. The most prominent clinical sign of the disease is irregular discolouration of the gills that can progress to gill rot. Other commonly reported clinical signs include anorexia, enophthalmia (sunken eyes), fin erosion, superficial haemorrhaging at the base of the fins, pale, irregular patches on the skin associated with excess mucus secretion and also under production of mucus where patches of skin have a sandpaper-like texture.

Figure 2. ***Severe gill necrosis (gill rot) seen in a koi carp suffering from KHV disease © W.H. Wildgoose***

Figure 3. ***Pale necrotic patch of skin and excess mucus secretion on the head of a common carp suffering from KHV disease***

Diagnosis of KHV disease

A record of clinical signs are important for diagnosis. Microscopic examination of formalin-fixed tissue sections reveals extensive cell proliferation and severe necrosis in the gill tissue. Nuclear changes may be observed in epithelial cells of the gills and kidney that indicate a herpesvirus infection. However, accurate diagnosis may be complicated by the presence of secondary parasite and bacteria infections. Virus particles may also be observed in infected tissues by electron microscopy if the tissues are sampled and fixed at the optimal stage in the infection. The virus can also be isolated in carp cell cultures, such as koi fin and common carp brain cells but the cell cultures are often not sufficiently robust for routine diagnostic use. The most sensitive diagnostic tool available is amplification and detection of virus DNA by PCR (8). However, a number of diagnostic laboratories around the world have developed PCR assays and there is now a need to standardise and validate the most sensitive and reliable assays. Given these weaknesses, a combination of three of the methods should be used for accurate diagnosis of KHV infection.

Control of KHV disease

KHV is not currently listed as a notifiable disease by the European Union nor by the Office International des Epizooties (OIE), which is the World Organisation for Animal Health. Consequently, there is no requirement for exporting countries to provide any health certification to show freedom from the disease. However, in a number of countries, ornamental fish trade organisations have introduced a number of initiatives in an attempt to control the spread of the disease. This has included the establishment of trade networks where wholesalers and importers are notified when the disease is diagnosed in batches of koi. Other initiatives include the establishment of disease-free broodstock and the provision of quarantine facilities for importers.

There is no treatment for KHV disease and no vaccines are currently available. Losses from the disease can be reduced by raising the water temperature above 27°C or lowering the temperature below 15°C. However, the surviving carp remain potential carriers of the virus and may transfer the disease to newly introduced carp stocks. Following a disease outbreak in a carp population it is recommended that all surviving fish are slaughtered and holding facilities completely disinfected following procedures recommended for Spring Viraemia of Carp disease (9). Ornamental carp importers and wholesalers have been advised to set up separate holding facilities at water temperatures favourable to the virus (20-26°C) and isolate or quarantine new batches of carp for a minimum of 2 weeks. During this isolation period no transfer of water between batches must be permitted including that on hands, nets, buckets, clothing, rubber boots or by aerosols (9).

The impact of KHV disease

KHV disease has had a considerable impact on intensive warm water carp culture. The extensive regional and international movements in live ornamental fish for trade and koi shows have undoubtedly contributed to the rapid global spread of the disease. Also, other factors such as the high turnover of fish at ornamental fish import sites and the lack of quarantine facilities and disease security have enhanced the severity of the outbreaks. Traditionally, ornamental fish are viewed as pets and therefore not covered by regulations for animals destined for human consumption. They are checked less stringently for diseases at border crossings, allowing KHV to pass freely between countries. In theory, ornamental fish are kept in closed systems and any disease outbreak is limited in economic and epidemiological terms, and not considered a national concern. However, it is evident that ornamental fish are often held in close contact with common carp that have been stocked into angling waters and KHV now poses a serious threat to our wild carp populations.

How are we responding to the problem?

Defra sponsored an international workshop on KHV in London, 12 -13 February 2004, that was attended by 45 delegates from eight countries including Israel, Japan, Indonesia, the USA and countries in Europe. The aim of the workshop was to raise the general awareness amongst regulators, scientists and the industry of the current status of KHV with respect to its management, identification and potential treatment. The final report of the workshop is available on the Defra website at www.defra.gov.uk/science/Publications/Default.asp.

Defra, in collaboration with the English Carp Heritage Organisation (ECHO), the Environment Agency and the Ornamental Aquatic Trade Association (OATA), is currently funding research studies at CEFAS on the impact of KHV on UK carp and the extent of KHV infection in UK angling waters and is also funding work on improvement and standardisation of assays and development of new assays to detect KHV.

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KOI HERPESVIRUS INTERNATIONAL WORKSHOP

Mark James, FRM Ltd, Coillie Bhrochain, Bonskeid, Pitlochry, Perthshire, PH16 5NP Scotland

Koi Herpesvirus is having a significant impact on fish welfare and the conduct of the international trade in ornamental fish. This workshop on Koi Herpesvirus (KHV), sponsored by Defra and organised by FRM Ltd., took place on the 12th-13th February in London. The concept was developed in recognition of the need to bring together key international stakeholders including members of the industry, scientists and regulators to ensure a common understanding of the status of this disease, its management and potential treatment. The workshop provided a focus for disseminating the latest information on the impact of the disease with respect to the ornamental industry and acted as a forum for discussing the latest practical management measures adopted to restrict the spread of the disease. Those actively involved in research into diagnostics and treatments for KHV were encouraged to exchange information, co-ordinate their activities and explore the possibilities for international collaboration. The workshop helped to identify key research requirements in this field.

The workshop proved to be a great success, stimulating international co-ordination activities within the industry to improve management of the disease throughout the supply chain. A number of contentious scientific issues related to the development of an attenuated vaccine and the production of ‘immune’ fish were discussed also.

Regional updates on the recorded incidences of KHV were provided by many of the countries most affected by the disease.

As a result of this workshop and a similar event that took place later in Japan, a Korean group, funded by the Japanese and the Israelies, have recently successfully sequenced the KHV genome. This genetic information will be fundamental to the development of vaccines against KHV.

Meanwhile, CEFAS Weymouth has continued to develop and assess methods to detect KHV infected fish. Defra hopes to support this activity further by providing resources for a sandwich student to work on KHV diagnostics.

Keith Davenport of the Ornamental and Aquatic Trade Association (OATA), successfully steered the workshop through a range of sensitive issues and, in collaboration with the Professional Koi Dealers Association, is developing an industry code of practice to help contain the spread of KHV. OATA also host a list server to encourage online information exchange on KHV issues.

A comprehensive report of the workshop is available on the Defra and FRM websites:
http://www.defra.gov.uk/science/Publications/Default.asp
or
http://www.frmltd.com (also carries copies of the workshop presentations).

INFORMATION FILE

BRITISH TROUT FARMING CONFERENCE, SPARSHOLT 2004

Wednesday 1st, Thursday 2nd and Friday 3rd September 2004

Wednesday 1st September

pm	Social events to be confirmed.
19.00	Skretting BBQ

Thursday 2nd September

09.00 – 10.00	Registration
Morning Chair:	Jonathan Jowett, Brow Well Fisheries Ltd.
10.05 – 10.15	**Welcome and Opening Address**: Tim Jackson, Principal, Sparsholt College Hampshire
10.15 – 10.40	**Food Safety Issues - Current and Future:**: Food Standards Agency Representative
10.40 – 10.45	**Discussion**
10.45 – 11.10	**The Vegetarian Trout**: Paul Morris, Skretting
11.10 – 11.15	**Discussion**
11.15 – 11.45	**Coffee**
11.45 – 12.10	**The Interaction of Wild and Stocked Trout**: Dominic Stubbing and Ravi Chatterji, The Game Conservancy Trust
12.10 – 12.15	**Discussion**
12.15 – 12.40	**Trout and Grayling Strategy**: Guy Mawle, The Environment Agency
12.40 – 12.45	**Discussion**
12.45 – 14.00	**Lunch**
Afternoon Chair:	Nick Read, Chairman, BTA
14.00 – 14.25	**Pheromones**: Colin Waring, The Institute of Marine Science, University of Portsmouth
14.25 – 14.30	**Discussion**
14.30 – 14.55	**European Trade Associations and Global Overview of Trout Production**: Courtney Hough, Federation of European Aquaculture Producers
14.55 – 15.00	**Discussion**
15.00 – 15.45	**Tea** (Sainsbury Building and Marquee)
15.30	AGMs BTA and QT (UK) Sainsbury Building ~ classroom
19.00	**Dinner reception**
19.30	**Conference Dinner**

Friday 3rd September

09.00 – 09.45	**Registration and Coffee**
Morning Chair:	Shaun Leonard, Sparsholt College
09.45 – 10.05	**Importation of Fish**: Alasdair Scott, CEFAS
10.05 – 10.10	**Discussion**
10.10 – 10.30	**Getting in Anglers**: Speaker T.B.A.
10.30 – 10.35	**Discussion**
10.35 – 11.05	**Coffee**
11.05 – 11.30	**Planning for Exotic Notifiable Fish Disease Outbreaks**: Ed Peeler, CEFAS
11.30 – 11.35	**Discussion**
11.35 – 12.00	**The Value of Optimal Feeding**: Anders Andreassen, Biomar A/S
12.00 – 12.05	**Discussion**
12.05 – 12.30	**Pain Perception in Fish**: Lynne Sneddon, University of Liverpool
12.30 – 12.35	**Discussion**
12.35 – 13.30	**Lunch**
Afternoon Chair:	Chris Gould, Schering-Plough Animal Health UK
13.30 – 13.55	**Fish Health and Welfare Legislation**: William Crowe, Scottish Quality Salmon
13.55 – 14.00	**Discussion**
14.00 – 14.25	**Parasites - What Next?**: Chris Williams, The Environment Agency
14.25 – 14.30	**Discussion**
14.30 – 15.00	**White Spot**: Andy Shinn, Institute of Aquaculture, University of Stirling
15.00 – 15.05	**Discussion**
15.05 – 15.25	**Strawberry Disease in Rainbow Trout in the UK**: Sophie Saint-Hilaire, CEFAS
15.25 – 15.30	**Discussion**
15.30	**Tea and Close of Conference**

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

PRESS RELEASE - TROUT WELFARE GIVEN £600,000 BOOST

The Department for Environment, Food and Rural Affairs (Defra) has committed £600,000 for two new trout welfare projects. The grants will fund collaborative research by scientists at Stirling and Bristol universities and the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) aimed at safeguarding and improving trout welfare. The research has also been given the backing of the British Trout Association and will involve sampling from commercial farms.

Dr James Turnbull of the University of Stirling's Institute of Aquaculture said: "These grants recognise the importance of fish welfare issues to the continued sustainability of fish farming. Fish are sophisticated animals, not the unfeeling creatures with a short memory that many people perceive them to be."

The first of the two projects will define acceptable water quality limits for safeguarding trout welfare, while the second will identify the husbandry and environmental factors that exacerbate fin erosion. A fundamental part of the research will be to identify key welfare measures that the industry can use to monitor and audit trout welfare.

For further information on the projects please contact
Dr James Turnbull – Institute of Aquaculture, University of Stirling
(Tel: 01786 467913; Email jft1@stir.ac.uk,
or
Dr Tim Ellis – CEFAS Weymouth
(Tel: 01305 206600; Email: t.ellis@cefas.co.uk)

Associated with these projects is a PhD veterinary studentship/Clinical Training Scholarship in Veterinary Epidemiology and Fish Welfare. Informal enquiries about this 3-year post can be made to Toby Knowles on 01179 289214 or Tim Ellis on 01305 206600. Applicants should be veterinary graduates who hold, expect to hold shortly, or are eligible to hold, membership of the RCVS.

THE FISH HEALTH INSPECTORATE AND YOU

STANDARDS OF SERVICE – CITIZENS CHARTER PERFORMANCE RESULTS

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

Introduction

The Fish Health Inspectorate (FHI) aims to provide an efficient, quality service. Our standards of service have always been high and we are constantly looking for ways to improve them. Under the terms of the Citizen's Charter we are required to publish an annual summary of the results of our performance against the standards set. The results are reported in the 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 increased by 50% against the previous year and continues to grow.

The following report shows the performance achieved against our target of 100%, for the period 1st April 2003 to 31st March 2004.

Achieved in 2003-04

CORRESPONDENCE

The Inspectorate's target is to reply to all letters, e-mails, faxes and complaints, within 10 working days of receipt. — 99.5%

IMPORT LICENCE APPLICATIONS

The Inspectorate has undertaken to issue import licences within 10 working days of receipt. — 99.9%

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. — 85%

Registration administration
The Inspectorate aim to complete the administrative action within a further 10 days from the date of the visit. — 96%

NOTIFIABLE DISEASES

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

Respond to other notifiable diseases within 2 working days. — 100%

REPORTING OF TEST RESULTS AND VISIT SUMMARIES

The FHI must report all negative test results within 5 working days of the full results becoming available and give a verbal report within 1 working day where a notifiable disease is found. We have agreed to provide a follow up letter within 10 working days to advise the farmers in writing of any points raised during the visit. — 69.3%

OVERALL RESULTS

The overall compliance rate with our set targets. — 89.4%

The total amount of correspondence received and recorded by the Inspectorate was 2422. Our performance fully met or approached our targets in most areas. We will continue to strive to achieve all our standards in 2004/ 2005.

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. The reporting of test results is often delayed where Inspectors involved in a disease investigation, are conducting other routine inspection duties when the results of that investigation become available. Other inspectors may not be able to 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 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.

UK AQUACULTURE R&D DATABASE

Mark James FRM Ltd, Coillie Bhrochain, Bonskeid, Pitlochry, Perthshire, PH16 5NP, Scotland

Aquaculture R&D in the UK is funded by a number of different bodies, with different remits and Policy agendas. Whilst some bodies provide information about the projects they fund, there has not previously been a common source of information. Defra therefore sponsored FRM Ltd to collate this information for all the main sponsors of aquaculture related R&D in the UK. This information is now available in a standard and searchable format as an online database on the Defra and FRM websites:
www.defra.gov.uk/science/areas/aquatic/default.asp.htm
or
www.frmltd.com

A full Microsoft Access version of the database is also available as a download on the FRM website. The database will be updated annually and a summary of the project data will be provided.

The database provides an important source for information on current and recently completed projects. Many of the projects are accompanied by abstracts, providing background information and contact details to allow interested parties to make further inquiries. The database will provide a strategic resource for all those involved in the management and co-ordination of aquaculture R&D and should help to minimise duplication of effort. Analysis of the database may help to contribute to a more strategic view of the scientific capacity for R&D in this sector. Scientific expertise may take many years to generate and it is important to identify trends in aquaculture R&D requirements to ensure that we have appropriate scientific expertise in place. This issue was raised recently at the Defra Fish Health review at Weymouth, where the shortage of experienced fish histopathologists was highlighted as an example.

The current database has been used to produce a summary of UK aquaculture R&D between 1999 and 2002. A copy of the report can be downloaded from both the Defra and FRM websites:
www.defra.gov.uk/science/Publications/Default.asp
or
www.frmltd.com

Summary of the report

The vast majority of expenditure on aquaculture related R&D between 1999 and 2002 was committed by a combination of Defra, SEERAD and the FSA. The total sum spent between 1999 and 2002 was approximately £15.5 million. The main areas of expenditure were in relation to Policy support and focused on fish disease, the environmental impact of aquaculture, and shellfish hygiene. The average project duration was 2.6 years (31 months), the average annual expenditure was £54,000 per project, and the average total project cost was £159,000. Between 1999 and 2002, the number of projects supported rose from 33 to 129, and the average increase in the level of investment in aquaculture related R&D reached 40% per year.

The number of aquaculture R&D sponsors, including minor sponsors increased between 1999 and 2002. Devolution and Government restructuring led to an increase in the number of public bodies with an interest in aquaculture. Improved organisation of industry trade bodies increased the visibility of the industry throughout the UK, and fora to improve co-ordination of industry relevant R&D have encouraged investment in this area. The three most significant sponsors of aquaculture related R&D were SEERAD, the Food Standards Agency and Defra, each contributing approximately a quarter of the total commitment between 1999 and 2002. The research councils, NERC (11.1%) and BBSRC (14.7%), contributed the majority of the remaining balance. Increased expenditure on aquaculture related R&D by BBSRC between 1999 and 2002 is of note and perhaps reflects a move towards funding topics of interest in terms of Government Policy support and commercial development. Only 2% of recorded total project costs were for co-sponsored projects which suggests that there is little multi-sponsor funding of individual projects.

Direct industry investment in R&D is difficult to quantify. The LINK Aquaculture programme which accounted for a significant proportion of expenditure on collaborative (Government and industry) R&D in the UK, estimates that industry contributed ~12% of total project costs in cash and ~38% in-kind between 1996 and 2001. Only the 'wealthiest' sectors of the industry make a significant direct investment in R&D – these tend to be the feed and the pharmaceutical companies. Commercial sensitivities generally preclude disclosure of the amounts committed to R&D by these companies. Scottish Quality Salmon (SQS) contribute cash to projects from levy funds. The British Trout Association (BTA) tends to form 'research clubs' where individual members contribute to specific projects. The Shellfish Association of Great Britain (SAGB), and the Association of Scottish Shellfish Growers (ASSG) generally contribute in-kind support. The British Marine Finfish Association (BMFA) has made minor cash contributions to projects, but has a history of providing in-kind support. The Ornamental Aquatic Trade Association (OATA) has only recently begun to participate in collaborative R&D but, like other sectors, has demonstrated the ability to provide co-ordinated in-kind support from its members. Individual pharmaceutical and feed companies have shown a willingness to be active participants in collaborative R&D contributing both cash and in-kind support.

Disease related R&D accounts for ~49% of expenditure with Defra and SEERAD contributing 52% and 33% respectively to the project costs in this area. For both organisations, the majority of this expenditure rests with their respective agency laboratories. Most of the disease work relates to salmonids. FSA expenditure on shellfish contamination issues is significant and accounts for much of 27% of recorded expenditure on shellfish aquaculture R&D. Environment related R&D accounts for ~27% of expenditure with the FSA contributing ~64%, almost exclusively devoted to shellfish hygiene issues. Salmonid and Marine Finfish aquaculture R&D account for ~30% and ~6% of recorded expenditure respectively.

If disease related research is not included under the definition of 'welfare', the main budget allocation to this subject is included in the 'Husbandry' category which accounts for only ~3% of total R&D expenditure. Both BBSRC and Defra increased their commitments to fish welfare related research, with BBSRC and Defra contributing more than 72% and 26% respectively of the total expenditure in this area. The molecular sciences (excluding disease studies) are mainly represented through genetics and physiological research and, in combination, account for 16% of total expenditure. Nutrition related studies absorbed 2.6% of total expenditure with reproductive and life stage research accounting for 1.2%. Economic and Market related research commanded less than 1% of total R&D expenditure. With respect to applied and commercially relevant studies, the need to integrate economic and market information with aquaculture research and development is acute. There is little evidence of funds being committed to the development of any novel species or processes for aquaculture since 1999. Most of the funds committed to the development of marine finfish farming relate to potential disease or environmental issues which may be of future concern if this sector expands. Few resources are being allocated to R&D in support of direct commercial development or known production constraints (other than disease) in this sector.

Overall, the dataset used to compile the summary is likely to be an underestimate of the total expenditure on aquaculture related R&D by UK sponsors during the period 1999-2002. However, given the comprehensive response provided by most of the major sponsors of work in this area, the dataset probably accounts for the majority of expenditure. At the time the database was compiled (June 2003) the overall commitment to aquaculture between 1999 and 2007 was at least £28.1 million. As a cumulative figure, this commitment will obviously increase as subsequent budgets are allocated to new projects.

BTA NEWS

Jane Davis, Chief Executive, British Trout Association, Bow Business Centre, London, E3 2SE

BTA representatives have met recently with the EA to discuss various matters including: the National Trout and Grayling Strategy, stocking, triploid brown trout production and performance, native brown trout broodstock, the Water Framework Directive, and escapes of farmed fish. Escapes from fish farms has long been an issue and can leave the farmer liable to damages and possible prosecution. The EA are determined to eliminate the problem of escapes, and the BTA has produced a briefing note on the 'Containment of Farmed Fish' which the EA have endorsed.

The UK's application to the European Commission for freedom from *Gyrodactylus salaris* for it entire territory, freedom from IPN (IoM), BKD (NI, IoM, J) and SVC (GB, NI, IoM, J, G), and programmes for the control and eradication of SVC (GB) and BKD (GB) has been decided. The commission recognised the applications for GS and SVC, and a revised application for BKD, but not that for IPN as it did not consider the eradication of IPN could be achieved under the national control programme. The Commission Decision, establishes the requirements for disease-free areas, the criteria for control and eradication programmes, and defines the additional guarantees required for introductions of live fish from EU and non-EU sources entering disease-free or controlled areas within the EU. Copies of the new controls are available at www.efishbusiness.com. The BTA will work with the regulatory authorities to look at the practicalities of the Commission's additional requirements implied by the additional guarantees, and assess whether the guarantees can and should be enforced.

On 1st May 2004, new EU animal health certification arrangements came into force to regulate imports from third countries of live fish, eggs and gametes intended for farming, and live fish of farmed origin intended for human consumption. Annexes provide lists of third countries eligible to import into the EU, and also amends the animal health certificate to incorporate the additional guarantees granted to the UK and some other member states.

The BTA will be involved in a new EU funded R&D project 'Aquatreat' aimed at developing best practice in treatment of fish farm effluents and subsequent use of retrieved solids and water. The BTA Whitespot research project at Stirling is continuing, aimed at developing a farm strategy to minimise the impact of *Ichthyophthirius*. Research is proceeding on several lines including: improving the presentation of medicated feed by using dressings and top-coatings; assessing the effectiveness of chemical treatments for theronts (the infective stage); determining whether infestations originate from the wild or proliferation within the site; and assessing the effect of husbandry practices on infection. The BTA is also supporting Defra funded trout welfare research on the causes and control of Fin Erosion and Water Quality Parameters. These two new projects continue the work already done on Stocking Density, and are an important element of the industry response to the Farm Animal Welfare Council Report into Farmed Fish. It is intended that 'welfare indicators' will be an outcome of the work, which would enable the general welfare conditions on a farm to be easily and speedily assessed. Work continues on the Defra funded research into ensiling fish waste with field trails about to begin. The Fallen Animals Scheme now looks likely to commence in autumn 2004, with trout farmers having access to it, probably through knackers yards. Renderers have agreed to take ensiled fish waste to the extent of 5% of their total tonnage. Costs are not yet settled but, with substantial government funding in the early years, this should be an economical disposal route.

The BTA has commissioned 12 new recipes and digital photography as part of its ongoing generic promotion of trout. The BTA uses these materials to promote trout, excite the media and press, and encourage them to feature trout. The BTA office has a trained spokesperson to respond to any media queries relating to issues pertinent to the industry. For example, the BTA has access to reports by the UK Food Standards Agency and the Fishmeal Information Network (FIN) on levels of dioxins and PCBs. Recent FSA monitoring as part of an EU programme showed that all fish sampled were below the EU limit (3 ng/kg), with levels in farmed trout (1.0 ng/kg) being half that of farmed salmon (2.3 ng/kg) and less than other wild marine fish (1.2-1.7 ng/kg). The FSA has stated that "there is no reason to avoid eating Scottish farmed salmon" and that there are no new safety concerns. FIN have responded to the recent media reports by clarifying certain points. The dioxin levels in farmed salmon are within the safety limits set by the World Health Organisation, the US Food and Drug Administration, and the European Union. Levels of dioxins have fallen by 85% over the last 20 years due to the decrease in industrial emissions, and milk and milk products contribute a similar amount of dioxins and PCBs to the diet.

A BRIEF GUIDE TO AQUACULTURE GRANTS AND FUNDING

Keith Jeffery,
FHI, CEFAS Weymouth Laboratory, Barrack Road, Weymouth, Dorset, DT4 8UB

Obtaining information on grant funding for aquaculture-related projects is not always easy for fish and shellfish farmers. The situation can vary considerably between different parts of England and Wales, as do the criteria used for determining whether projects are funded in different schemes. The aim of this article is to provide pointers to various sources of funding and advice to assist farmers in inquiring into their own areas of interest.

Financial Instrument for Fisheries Guidance (FIFG)

This is the EU structural fund for fisheries and aquaculture. Grants are available for expenditure under various headings, one of which is aquaculture. Grant rates and eligible expenditure vary between different areas of the UK, depending on local spending priorities and the funds available.

In Cornwall and the Isles of Scilly and parts of Wales, funding is available for investment in aquaculture facilities before the point of harvest. This could include the construction, modernisation or equipping of fish farms. Aid is also available for processing and marketing operations after the point of harvest, for example smoking or packing facilities. In the rest of England, grants for pre-harvest facilities are not available, although grants are available for investments in the processing and marketing of aquaculture products.

For more details on eligible expenditure and grant rates please see

www.defra.gov.uk/fish/grants.htm

or contact Defra,
Room 308, East Block, 10 Whitehall Place,
London, SW1A 2HH.
Tel (English Applications): 020 7270 8045;
(Enquiries) Merseyside Applications: 020 7270 8048;
Fax: 020 7270 8019; email: fifg.grant@defra.gsi.gov.uk.

In Cornwall and the Isles of Scilly please see

www.swpesca.co.uk

or contact Ms Clare Leverton, South West PESCA Ltd,
Trevint House, Strangway Villas, Truro,
Cornwall TR1 2PA.
Tel: 01872 270333; Fax: 01872 242470;
email: clare@swpesca.prestel.co.uk.

Farmers in Wales should be aware of Opportunity Wales who provide similar help for Objective 1 areas and can also provide information on the Princes Trust. See

www.opportunitywales.co.uk

or Tel: 0845 8500 888.

Services

- Beta Technology Limited provides assistance to small and medium sized enterprises to obtain European funding for research and development projects, and by providing innovation services to companies to help them develop, promote and acquire new technologies. Beta is the designated UK National Contact Point (NCP) for SMEs for co-operative research within the EU's Sixth Framework Programme. Please see

  www.betatechnology.co.uk

  or contact Beta Technology Ltd.,
  Barclay Court, Doncaster Carr, Doncaster,
  South Yorkshire, DN4 5HZ.
  Tel: 01302 322633.

- Throughout Europe there is a network of European Information Centres that can provide fund-matching services that allows companies and other organisations to identify relevant funding opportunities. This is not restricted to specific organisations or sectors, but is open to all organisations and businesses in the relevant region that wish to explore funding opportunities. For information on all offices please see

  http://europa.eu.int/comm/enterprise/networks/eic/eic-geo_cover_en.html

  An example of one of these centres is the Southern Area European Information Centre at

  www.euro-info-centre.co.uk

  or contact Southern Area EIC,
  Northguild, Civic Centre, Southampton, SO14 7LW.
  Tel: 023 8083 2866.

- The Welsh European Funding Office also offers a similar match funding service at

  www.wefo.wales.gov.uk

  or Tel: 01443 471100;
  e-mail: enquiries-wefo@wales.gsi.gov.uk.

- The Business Link service is often able to provide further information on funding at a local level and provide further business services. Examples of websites for these being

www.businesslinkwessex.co.uk
www.blinkdandc.com

- The Seafish Industry Authority (Seafish) has two aquaculture development officers who can provide help and assistance to fish farmers and prospective fish farmers. Please see

www.seafish.org/sea/aquaculture.asp

- Additionally there is various information that can be found on-line that has been written by consultants and includes other areas such as Lottery funding.

LANTRA NEWSLETTER

Lantra is the Sector Skills Council for the Environmental and Land-based Sector. Lantra is licensed by the UK Government to drive forward the new skills, training and business agenda for the sector. Lantra represents the interests of over 400,000 businesses and 1.5 million workers in the environmental and landbased industries in the UK, including animal care. They have recently issued a Newsletter for the aquaculture industry. The following items are selected from this publication.

Introducing the aquaculture industry group

To ensure that Lantra's work is industry-led and effectively meets the true needs of the aquaculture industry, an Industry Group meets and communicates regularly to steer priorities and actions on skills, training and business development issues.

"Lantra plays a critical role in embedding a training culture throughout the aquaculture industry and in promoting the self evident philosophy that training is an investment, not a cost." *Doug McLeod, Industry Group Chair*

Industry Action Plan

An industry-specific action plan is helping the aquaculture industry meet its skills and workforce development needs. The Industry Action Plan, developed following consultation with the industry group and the wider network, identifies priority issues currently impacting on the industry, and provides a well-needed focus for addressing these challenges. Key priorities identified in the Action Plan include:

- Tactical research to provide clear and robust information on future needs, current skills gaps and the necessary learning supply for aquaculture
- Coherent qualification routes and career pathways
- Greater interaction between Higher Education and the industry
- Supporting the industry's awareness and understanding of changing skills and learning needs, in light of constant changes in legislation, markets and technology
- Addressing the current image of industry to ensure successful recruitment and a sustainable industry
- Promoting all levels of training and educational opportunities both within and outwith the industry

Progress to date against the action plan has been significant. Feedback is currently being sought on how the plan should be developed to build on progress.

Scottish Modern Apprenticeship approved for Aquaculture

A Scottish Modern Apprenticeship in Aquaculture has been developed and approved, following significant interest from aquaculture employers - providing a tailored solution to the industry's need for employees who can combine technical knowledge with practical skills.

Modern Apprenticeships are a route by which people can begin a career in aquaculture, learn practical skills and achieve nationally recognised qualifications. They are government backed training schemes aimed primarily at young people aged between 16-24, however in certain regions funding is available for older people.

Candidates enrolling on the Aquaculture Scottish Modern Apprenticeship will gain the nationally recognised Aquaculture Scottish Vocational Qualification (SVQ), in addition to the Core Skills of communication, working with others, problem solving, IT and numeracy. Apprentices also gain industry-specific certificates appropriate to their own circumstances and the business in which they work, such as Sea Survival, a Fish Vaccination Course, or Emergency First Aid. For more information about Modern Apprenticeships, contact Karen Lawlor on 02476 858432 or email karen.lawlor@lantra.co.uk.

FREE SkillChecks in Wales

Lantra is offering free training needs assessments to aquaculture businesses in Wales. Any training needs identified by the 'SkillCheck' could be funded by up to 50% and could include a range of courses from business management and IT to practical skills courses and online learning. For more information, contact Philippa Davies on 07867 908188 or email philippa.davies@lantra.co.uk.

Scottish Progression Awards

If you work in the Aquaculture industry, or are thinking about a career in Aquaculture, you might be interested in the Scottish Progression Award (SPA) in Aquaculture. This new qualification is suitable for anyone who would like an introductory course in Aquaculture. You could be working part-time in the industry and want a qualification, or perhaps at school or college and want to see if the industry suits your needs? The SPA will equip you with the basic skills, knowledge and understanding to work in the industry. It will help you progress to more advanced qualifications, such as the Scottish Vocational Qualifications (SVQs) at Level 2 and 3 in Aquaculture, or eventually to a HNC. For more information about the Scottish Progression Award in Aquaculture, visit www.lantra.co.uk or contact Billy Sweeney on 07867 908184 or email billy.sweeney@lantra.co.uk.

Lantra's New Look Website

Lantra has launched a new and improved version of its website, including a section dedicated to Lantra's work for the aquaculture industry. At www.lantra.co.uk/aquaculture, you can sign up to receive Lantra's latest news, find out how to access work-based and online training, download Lantra's Action Plan for Aquaculture and view the latest National Occupational Standards, research findings, strategic documents and much more!

Further information

If you would like to get involved in Lantra's activities, please contact Tricia Bloomfield on Tel: 01620 822633 or email tricia.bloomfield@lantra.co.uk.

WHERE TO GET HELP AND ADVICE

Policy Matters

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

Fish farming policy:-
Fisheries Division IIA, Room 110, East Block,
10 Whitehall Place, London, SW1A 2HH
(Tel. 020 7270 8826) (Fax. 020 7270 8827)

Grant Aid:-
Fisheries Division 1B, Room 308, East Block,
10 Whitehall Place, London, SW1A 2HH
(Tel. 020 7270 8045) (Fax. 020 7270 8019)

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

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

The 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,
Bow Business Centre, London E3 2SE
(Tel. 020 8980 2456) (Fax. 020 8983 3289)
www.britishtrout.co.uk

Wildlife conservation

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

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

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

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

Other Useful Numbers

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

DEFRA-CARD FUNDED TROUT R&D

Mark James, FRM Ltd, Coillie Bhrochain, Bonskeid, Pitlochry, Perthshire, PH16 5NP, Scotland

A number of important trout related projects are now being funded, or are under consideration as part of the Defra budget allocated through the Committee for Aquaculture Research and Development (CARD).

Antifungal Treatments – Preliminary international screen for potentially registerable compounds for the treatment of aquatic fungal diseases in salmonids.
Last year, Defra in collaboration with Scottish Quality Salmon (SQS) commissioned Triveritas 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. Triveritas have now completed their initial sift of compounds and assessed the willingness of the companies, who own or hold the licences for these substances, to use the most promising in efficacy trials. Several compounds have been highlighted as possible antifungal candidates that could potentially be useful for treating salmonids.

The success of this project has encouraged Defra and, in principle, SQS to consider a follow-on project which will provide a structured *in vivo* and *in vitro* efficacy testing framework for assessing the most promising compounds. Triveritas are preparing a proposal which, if successful, will begin later this year.

Genetics of Proliferative Kidney Disease (PKD) resistance in rainbow trout
This PhD studentship supported by Defra, the University of Stirling and the British Trout Association will identify the levels of genetic resistance to PKD, a major fish parasite that can cause high mortality in young trout and is a major cause of lost production in trout farms on affected rivers and streams. This project will contribute to the wider assessment of the potential to develop a selective breeding programme to produce rainbow trout strains resistant to PKD and other trout related diseases. The project began in October 2003 and will be completed by October 2006.

Selective improvement of rainbow trout: mass selection and markers (LINK Project TRT12)
This was one of the last LINK Aquaculture projects to be commissioned by the Natural Environment Research Council in June 2001 and is due to be completed by July 2004 The project is being conducted by the University of Stirling in collaboration with the British Trout Association.

This research is giving a significant impetus to the management and genetic improvement of the UK rainbow trout genetic resource to increase the profitability and long-term sustainability of the industry. This is being achieved through a programme of mass selection that utilises the latest quantitative genetic and molecular fingerprinting techniques to maximise genetic improvement and minimise strain degradation through inbreeding. It is now clear that significant future improvements in efficiency will only come through the development of better-adapted commercial strains as in other animal production systems.

The project is attempting to improve growth rate, flesh pigment retention, better carcass quality (resulting in less processing waste) as well as promoting characteristics of later maturing and more disease resistance. Disease resistance seems to be the most important trait for the industry at the moment.

Family-based breeding designs have been planned with the objective of obtaining the maximum amount of genetic information. The planned designs have been implemented with broodstock from three different farms, and data on performance and PKD mortality are being collected. Good collaboration from the industry partners has enabled the trials to be larger than initially planned. Protocols for identifying individual fish using DNA markers (i.e. microsatellites) are in place. In addition some extra work to be done as part of a nutrition trial will add value to the project by increasing the commercially important traits to be analysed.

The benefits likely to arise from this programme are at two levels. The first is the cumulative annual increase in production quality of better-adapted UK rainbow trout strains and the increasing profitability of the farmers using them. The second is that with the development of better adapted later maturing and more disease resistant strains the industry will be able a move away from all-female production systems, with the limitations and management this requires.

Development of a management system for the control of the ciliate protozoan *Ichthyophthirius multifiliis*
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 current, acceptable means for the treatment

of *I. multifiliis*. An earlier LINK aquaculture project (TRT06) carried out by a University of Stirling group, however, identified a number of potential in-feed chemotherapeutants against *I. multifiliis*. The main objective of the proposed project seeks to trial these compounds in the field and to build their use into a strategy for the control of the parasite in trout farms. Control of the parasite within farm environments would reduce fish mortalities, minimise re-infection of farmed fish, and decrease the number of infective stages leaving the farm and entering natural water courses. This one year project is sponsored by Defra and the BTA and is due to end in October 2004.

The effect of stocking density on the welfare of farmed rainbow trout

This project will end in June 2004 and was supported by Defra Animal Welfare and Fish II, together with the BTA. Conducted by CEFAS Weymouth and the University of Stirling, the project has developed a non-invasive stress assay to quantify the amounts of cortisol, the classic stress hormone, released into water. This novel methodology has been coupled with other indicators of stress and condition to provide a suite of welfare indicators to assess the effects of stocking densities. Within the last year of the project the field sampling of commercial farms was extended, allowing a more detailed application of various welfare indicators across a wider range of farming conditions. Complex multivariate statistical techniques were also applied to enhance scrutiny of the collected data. Defra is continuing to support work in this area through its Animal Welfare Division. The effects of water quality deterioration on trout welfare and the role of density in fin erosion are presently being followed up in two new projects (AW1204 and AW1205). An integral part of these projects will be to further develop methodology to provide a simple means for quantifying welfare status on farms. The research is being conducted by a consortium of the Institute of Aquaculture - Stirling, CEFAS Weymouth, and Bristol University, and is supported by the BTA.

In the pipeline!

Two projects of great significance to the trout sector are currently under consideration by Defra. Over the past decade, Defra has sponsored a considerable body of R&D on both PKD and Rainbow Trout Fry Syndrome (RTFS). In combination with technological developments in the field of immunology, this work has now culminated in the potential to develop vaccines for these diseases. Two proposals with an impressive level of industrial support are now at an advanced stage of preparation which, provided they pass the scrutiny of scientific peer review, should begin by October of this year.

RESEARCH NEWS

1. German study of contaminant uptake from food by trout

This study examined the transfer of polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) from commercial fish feed into the edible flesh of rainbow trout under normal rearing conditions. Trout were fed with high-energy feed for salmon (fat content 26-30%) for 19 months and the fish increased from 10 to 2092 g. Considerable amounts of PCDDs and PCDFs were transferred from the fish feed into the tissue of the trout. Dioxin concentrations increased during the time of feeding from 0.05 to 0.91 ng WHO-PCDD/F-TEOs kg^{-1} wet weight and from 5 to 16 ng WHO-PCDD/F-TEOs kg^{-1} fat. A correlation was found between the dioxin concentration of the feed and the resulting concentration in the fat of the muscle tissue. The data provides transfer rates from a high-energy diet to farmed rainbow trout.

Karl, H. (Fed Res Ctr Fisheries, Inst Fishery Technol & Fish Qual, Palmaille 9, D-22767, Hamburg, Germany. Email: horst.karl@ibt.bfa-fisch.de), Kuhlmann, H. and Ruoff, U. (2003). Transfer of PCDDs and PCDFs into the edible parts of farmed rainbow trout, *Oncorhynchus mykiss* (Walbaum), via feed. *Aquaculture Research*, 34: 1009-1014.

2. US study on health risks of consuming farmed salmon

This study analysed over 2 metric tons of farmed and wild salmon from around the world for organochlorine contaminants, and found that concentrations of these contaminants were significantly higher in farmed salmon than in wild fish. European-raised salmon had significantly greater contaminant loads than those raised in North and South America, indicating the need for further investigation into the sources of contamination. The authors concluded that their risk analysis indicated that consumption of farmed Atlantic salmon may pose health risks that detract from the beneficial effects of fish consumption.

Hites, R.A. (Indiana Univ, Sch Publ & Environm Affairs, Bloomington, IN 47405, USA. Email: HitesR@Indiana.edu), Foran, J.A., Carpenter, D.O., Hamilton, M.C., Knuth, B.A. and Schwager, S.J. (2004). Global assessment of organic contaminants in farmed salmon. *Science,* 303(5655): 226-229.

3. US study indicates benefits of fish consumption outweigh potential risks

The objective of this study was to evaluate the potential health benefits and risks related to the consumption of fish or fish oil. The nutritional benefits of fish consumption relate to the utilisation of proteins of high biological value, as well as certain minerals and vitamins that fish provide. In addition fish or fish oil contains omega-3 polyunsaturated fatty acids (PUFAs) that appear to play several useful roles for human health. Conversely, some carcinogenic contaminants are also stored in the adipose tissue of fish. Health benefits related to the consumption of fish or omega-3 PUFAs were obtained by an extensive literature search. Scientific data indicate that the consumption of fish or fish oil containing omega-3 PUFAs reduces the risk of coronary heart disease, decreases mild hypertension, and prevents certain cardiac arrhythmias and sudden death. Potential health risks related to carcinogenic contaminants (e.g. dioxin, PCB, etc.) in fish were estimated using the U.S. EPA-approved cancer risk assessment guidelines and evaluated by comparison to the acceptable excess risk level of 10^{-6} to 10^{-4}. Risk estimates in humans for carcinogenic environmental contaminants in fish ranged from an excess risk level of 3×10^{-6} to 9×10^{-4} which meet acceptable excess risk level criteria. Therefore, consumption of fish in accordance with the State of Michigan Fish Advisory Guidelines is safe and should be encouraged. The top 11 fish species [sardines, mackerel, herring (Atlantic and Pacific), lake trout, salmon (chinook, Atlantic, and sockeye), European anchovy , sablefish, and bluefish] provide an adequate amount of omega-3 PUFAs (2.7-7.5 g/meal) and appear to meet the nutritional recommendation of the American Heart Association.

Sidhu, K.S. (Michigan State Univ, Inst Environm Toxicol, C231 Holden Hall, E Lansing, MI 48824, USA. Email: sidhuk@msu.edu) (2003). Health benefits and potential risks related to consumption of fish or fish oil. *Regulatory Toxicology and Pharmacology,* 38: 336-344.

4. Cooking method affects nutritional quality of trout

The effects of different cooking methods (frying, boiling, baking, grilling, microwave cooking) on the composition and mineral content of rainbow trout were determined. Mean moisture, protein, ash and fat contents of raw fish were 73.4, 19.8, 1.4 and 3.4% respectively. Cooking had a considerable effect on the proximate composition, with significant changes in dry matter, protein and ash contents found for all cooking methods. Frying increased the fat content of samples but the other cooking methods did not. Cooking also affected the mineral composition. The Mg, P, Zn and Mn contents of fish cooked by almost all methods significantly decreased. The Na and K contents in microwave cooked samples increased, and the Cu content increased in fried samples. Losses of mineral content in boiled fish were higher than those of fish cooked by other methods. Baking and grilling were found to be the best cooking methods for healthy eating.

Gokoglu, N. (Akdeniz Univ, Agr Fac Food Engn Dept, Antalya, Turkey; Email: nalan@agric.akdeniz.edu.tr), Yerlikaya, P. and Cengiz, E (2004). Effects of cooking methods on the proximate composition and mineral contents of rainbow trout (*Oncorhynchus mykiss*). *Food Chemistry,* 84: 19-22.

5. German review of potential for TSEs in fish

Prion diseases are fatal neurodegenerative disorders in man and animals associated with the conversion of cellular prion protein (PrPC) into a pathologic isoform (PrPSc). This review summarises the present knowledge of prion proteins in fish. Recently, cDNAs coding for prion proteins have been identified in Atlantic salmon and Japanese pufferfish. It can therefore be expected that PrP genes are present in most, if not all, fish species. Fish therefore fulfil the general precondition to develop a prion disease. The review also addresses to what extent fish may have received potentially BSE contaminated animal meal, the chances of fish contracting a TSE by uptake of the BSE agent, and the potential risks associated with the use of fish for animal feed and human consumption.

Oidtmann, B. (Inst Zool Fischereibiol & Fischkrankheiten, Kaulbachstr 37, D-80539 Munich, Germany. Email: B.Oidtmann@zoofisch.vetmed.uni-muenchen.de), Baier, M. and Hoffmann, R. (2003). Detection of prion protein in fish - how likely are transmissible spongiform encephalopathies in fish? *Archiv fur Lebensmittelhygiene,* 54: 141-145.

6. Norwegian study of heart shape in farmed salmonids

The normal shape of the salmonid heart ventricle is a triangular pyramid with the apex pointing caudoventrally. A strong positive correlation has been established between this shape and optimum cardiac output and function. Domesticated salmonids appear to have developed a more rounded ventricle with misaligned bulbus arteriosus. Several reports from fish health veterinarians indicate that fish with abnormal heart morphology have a high mortality rate during stress-inducing situations like grading, transportation and bath treatments. The present paper compares and describes the ventricle morphology of wild vs. farmed Atlantic salmon, and wild steelhead (anadromous rainbow trout) vs. farmed rainbow trout. Several parameters were measured to provide numerical measurement of the differences in shape, i.e. height: width ratio and the angle between the longitudinal ventricular axis and the axis of the bulbus arteriosus.

The results indicate that the hearts of farmed fish are rounder than those in corresponding wild fish, and that the angle between the ventricular axis and the axis of the bulbus arteriosus is more acute in wild fish than in their farmed counterparts. Further studies are necessary to reveal the prevalence, functional significance and possible causes of these abnormal hearts.

Poppe, T.T. (Norwegian Sch Vet Sci, Inst Morphol Genet & Aquat Biol, POB 8146 Dep, N-0033 Oslo, Norway. Email: trygve.poppe@veths.no), Johansen, R., Gunnes, G and Torud, B. (2003). Heart morphology in wild and farmed Atlantic salmon *Salmo salar* and rainbow trout *Oncorhynchus mykiss*. *Diseases of Aquatic Organisms,* 57: 103-108.

7. Sand filtration to remove infective stages of parasites

This study explored the use of rapid sand filtration as a means of removing triactinomyxon actinospores (TAMS), the waterborne infective stage of the salmonid parasite *Myxobolus cerebralis* that causes whirling disease, from contaminated water. Initially, a batch of sand was sieved to create 12 size ranges from 0.18 to 2 mm, and these fractions were tested for their efficacy of removing TAMS through sand beds either 2 cm or 4 cm deep. The critical size at which no TAMS passed through the sand bed was 0.3 mm at 2 cm depth and 0.425 mm for a 4 cm bed depth. Additional tests evaluated the passage of TAMS through filter beds comprised of sand that had all particles smaller than 0.18 mm removed. With this sand, 0.2% of TAMS passed through a 2 cm bed, and none passed through a 4 cm sand bed. Based on these preliminary results, small (61 cm x 15 cm) rapid sand filters were placed in-line with aquaria containing rainbow trout fry. The sand bed depth was 10 cm under which lay 10 cm of aquarium gravel. Four treatments were (1) negative control, (2) positive control, (3) sand of >0.18 mm, (4) sand of >0.3 mm. TAMS were regularly introduced to the rearing systems above the sand filters. After 60 days, clinical signs of whirling behaviour and black tails were seen among the positive controls. A PCR assay indicated the negative controls and >0.18 mm group were still disease free. All positive control fish were infected, and 49% of >0.3 mm fish were infected. These results demonstrate that sand filtration may be a viable option in treating hatchery water supplies that are contaminated with whirling disease.

Arndt, R.E. (Fisheries Expt Stn, 1465 W 200 N, Logan, UT 84321, USA. Email: ronneyarndt@utah.gov) and Wagner, E.J. (2003). Filtering *Myxobolus cerebralis* triactinomyxons from contaminated water using rapid sand filtration. *Aquacultural Engineering,* 29: 77-91.

8. Golden trout are susceptible to PKD

This study describes an outbreak of proliferative kidney disease in farmed California golden trout *Oncorhynchus mykiss aguabonita* in the United Kingdom. The fish displayed the clinical signs of the disease, such as characteristic swelling of the posterior kidney and spleen. Infection of the renal tissue with *Tetracapsuloides bryosalmonae* was confirmed by means of electron microscopy and immunohistochemistry using a monoclonal antibody specific to *T. bryosalmonae*. This is the first study demonstrating susceptibility of California golden trout to PKD.

Morris, D.J. (Univ Stirling, Inst Aquaculture, Stirling FK9 4LA, Scotland. Email: djm4@stir.ac.uk), Longshaw, M. and Adams, A. (2003). California golden trout *Oncorhynchus mykiss aguabonita* are susceptible to proliferative kidney disease. *Journal of Aquatic Animal Health,* 15: 184-187.

9. US study on effects of hook types

There has been a number of recent innovations in bait tackle and techniques which should reduce or eliminate immediate post-capture mortality in bait angling. This study examined whether these new introductions could enable bait fishing to be used in hook and release fisheries where currently only artificial flies are permitted. Hatchery rainbow trout were caught from cages using circle hooks, the new Shelton self-releasing hooks, standard J hooks, treble hooks, and artificial flies (all barbless). Except for those caught on artificial flies, the fish were encouraged to swallow the hook, which was baited with Berkley Powerbait, a pasty attractant popular in eastern California. Data was recorded on the hook location within the fish, post-capture survival and weight change over the following 26 days. All artificial flies and at least 70% of the circle hooks lodged in the mouth or jaw, whereas most Shelton, J, and treble hooks (78, 65, and 63%, respectively) lodged in the oesophagus. Flies, circle hooks and Shelton hooks were extracted from the fish, and the lines were cut on the J and treble hooks. All fish caught with flies, J hooks (line cut), and netted controls survived the observation period. The survival of fish caught on the Shelton, cut-line treble, and extracted circle hooks was 98, 98, and 91%, respectively. The growth of cut-line J-hook fish was somewhat below that in other groups. The results from a second experiment showed that the Shelton hooks can be effective (0.7% mortality in 60 d), and a third study suggested that much larger fish suffer only slightly greater mortality from flies, cut-line circle hooks, and Shelton hooks (0.7, 3.3, and 4.7%, respectively). Since no significant differences in the long-term mortality and growth effects between some bait techniques and artificial flies could be demonstrated, the use of the former should be recommended to anglers and perhaps reconsidered in waters where bait angling is not currently allowed.

Jenkins, T.M. (Spooky Meadow Inst Trout Ecol, POB 336, June Lake, CA 93529, USA. Email: tjenk@gte.net) (2003). Evaluating recent innovations in bait fishing tackle and technique for catch and release of rainbow trout. *North American Journal of Fisheries Management,* 23: 1098-1107

10. Study of stress caused by angling

This study compared the stress response of rainbow trout elicited after capture by angling with that caused by transportation, stocking and capture by drag netting. Angling resulted in the lowest stress response, when compared to the other treatments. Drag netting and transportation resulted in high primary and secondary stress reactions. All the stress responses were transitory. The results suggest that catching fishes individually by angling is less stressful than other practices common in aquaculture.

Wedekind, H. (Inst Inland Fisheries Potsdam Sacrow, Jaegerhof Sacrower See, D-14476 Gross Glienicke, Germany) and Schreckenbach, K. (2003). Investigations on the effect of angling on stress response in rainbow trout. *Bulletin of the European Association of Fish Pathologists,* 23: 235-240.

11. Noise can affect fish

Fish are often exposed to environmental sounds such as those associated with shipping, seismic experiments, sonar and/or aquaculture pump systems. While efforts have been made to document the effects of such anthropogenic sounds on marine mammals, the effects of excess noise on fishes are poorly understood. This study examined the short- and long-term effects of increased ambient sound on the stress and hearing of goldfish (a hearing specialist). Fish were held under either quiet (110-125 dB re 1 muPa) or noisy (white noise, 160-170 dB re 1 muPa) conditions. Noise exposure did not produce long-term physiological stress responses, assessed from plasma cortisol and glucose levels, although a transient spike in plasma cortisol did occur within 10 min of the noise onset. The hearing capabilities were assessed from auditory brainstem responses. Goldfish had significant threshold shifts in hearing after only 10 min of noise exposure, and these shifts increased linearly up to approximately 28 dB after 24 h of noise exposure. Further noise exposure did not increase threshold shifts, suggesting an asymptote of maximal hearing loss within 24 h. After 21 days of noise exposure, it took goldfish 14 days to fully recover to control hearing levels. This study shows that hearing-specialist fishes may be susceptible to both noise-induced stress and hearing loss.

Smith, M.E. (Univ Maryland, Dept Biol, College Pk, MD 20742, USA; Email: mesmith@umd.edu), Kane, A.S. and Popper, A.N. (2004). Noise-induced stress response and hearing loss in goldfish (*Carassius auratus*). *Journal of Experimental Biology,* 207: 427-435.

12. Tank covers improve trout growth

This study evaluated partial tank covers for their effects on the growth of juvenile feral McConaughy strain rainbow trout during hatchery rearing. Rearing trials were carried out in 1999 (55 days) and 2000 (34 days) in circular tanks that were either completely open on top or partially (29%) covered. No significant differences in mortality were observed in fish reared with or without partial covers. In 1999, the trout reared in tanks with partial covers were significantly longer (93 v 88 mm), the total weight gain was significantly greater (23.9 versus 22.7 kg/tank) and feed conversions were significantly improved (0.83 versus 0.87). In 2000, the trout reared in tanks with partial covers were again significantly longer (81 v 78 mm) and the total weight gains were higher (15.4 v 13.5 kg/tank) and feed conversion was better (0.90 and 1.05), although the latter two measures of performance were not significantly different.

Barnes, M.E. (South Dakota Department of Game, Fish, and Parks, McNenny State Fish Hatchery, 19619 Trout Loop, Spearfish, South Dakota 57783, USA) and Durben, D.J. (2003). Effects of partial tank covers on the growth of juvenile feral rainbow trout during hatchery rearing. *North American Journal of Aquaculture,* 65: 344–348.

13. Review of recirculating systems for arctic char

Arctic char tolerate high-density culture conditions, have an excellent fillet yield, are amenable to niche marketing, and are suitable for production within super-intensive recirculating systems. Much of the North American production of Arctic char has been within recirculating systems, which can provide optimum water temperatures for fish growth and can also overcome limitations created by a lack of high-quality water resources or strict pollution discharge limits. This review examines several state-of-the-art facilities and describes several areas where advances have been made in cold-water recirculating system design in order to improve water quality, allow high feed loadings to be maintained and production capacity to be increased. Several critical process improvements include: increased hydraulic exchange rates through the culture tank, superior culture tank designs, better oxygen control strategies and ozonation, improved design of forced-ventilated cascade aeration columns, full flow drum filtration, and better pipe and sump cleanout designs. Several of the strengths and weaknesses of Arctic char production within land-based recirculating systems are also discussed.

Summerfelt, S.T. (Inst Freshwater, Conservat Fund, POB 1889, Shepherdstown, WV 25443, USA. Email: s.summerfelt @freshwaterinstitute.org), Wilton, G., Roberts, D., Rimmer, T. and Fonkalsrud, K. (2004). Developments in recirculating systems for Arctic char culture in North America. *Aquacultural Engineering,* 30: 31-71.

14. Refrigeration of trout gametes and embryos

The study examined whether the refrigeration of rainbow trout gametes and early embryos would be a suitable, reliable and efficient tool for prolonging their availability. The study was conducted during fall, winter, and spring spawning seasons. In all, more than 500 experimental variants were performed involving individual samples from 26 females and 33 males. On average, oocytes from optimal sources retained full fertilisation viability for seven days of chilled storage. Spermatozoa, regardless of storage method, retained full fertilisation ability for the first week of storage. Average survival rate of embryos refrigerated for 10 days and then transferred to regular incubation temperatures of 9-14°C was 92%. No effect of gamete and embryo refrigeration on the occurrence of developmental abnormalities was observed. Cumulative refrigeration of oocytes and embryos resulted in an average embryo survival rate of 71% in optimal source variants after 17 days of refrigeration (7 days oocytes+10 days embryos). The study shows that both gamete and embryo refrigeration can be successfully used as an efficient tool for prolonging availability of rainbow trout embryos in early developmental stages.

Babiak, I. & Dabrowski, K. (Ohio State Univ, Sch Nat Resources, 2021 Coffey Rd, Columbus, OH 43210, USA. Email: dabrowski.1@osu.edu). (2003). Refrigeration of rainbow trout gametes and embryos. *Journal of Experimental Zoology Part A-Comparative Experimental Biology,* 300A: 140-151.

15. Improving the motility of sex-reversed sperm

In this study spermatozoa was collected from the testes and the sperm duct of normal rainbow trout. It was incubated in artificial seminal plasmas of various pHs, and its motility examined in physiologically balanced salt solution. Although spermatozoa collected from the sperm duct were motile, the spermatozoa collected from the testes were immotile. However, suspending and incubating the testicular spermatozoa in artificial seminal plasma of pH 9.9 for 2 h at 4°C, increased the percentage of motile spermatozoa from 0.5% to 80%. The spermatozoa remained motile for at least 2 min after long-term incubation (12 h). When eggs were inseminated with untreated testicular spermatozoa or testicular sperm treated for 2 h at high pH, the percentage survival increased from 5.5% to 53.8% at the eyed stage due to the high-pH treatment. It was shown that the motility of spermatozoa collected from the testes of the sex-reversed male (XX) that had lost its sperm duct was improved by incubation in high-pH artificial seminal plasma. The study suggests that it is possible to markedly increase the mass production efficiency of all-female or all-female triploid sterile progenies.

Kobayashi, T. (Kinki Univ, Fac Agr Dept Fisheries Lab Aquat Biol, Nara 6318505, Japan. Email: kobayasi@nara.kindai.ac.jp), Fushiki, S. and Ueno, K. (2004). Improvement of sperm motility of sex-reversed male rainbow trout, *Oncorhynchus mykiss*, by incubation in high-pH artificial seminal plasma. *Environmental Biology of Fishes,* 69: 419-425.

16. Rearing temperature affects gender in sockeye salmon

This study examined thermolability in phenotypic expression of sex in hime salmon - a land-locked type of sockeye salmon which is a commercially valuable species in cold-water lakes of Japan and expected to have good potential for aquaculture. Eyed-eggs or alevins of genetically all-female fish were subjected to high temperature. Water temperature was raised from 9 to 18°C either (1) in the middle of the eyed-egg stage, 42 days post-fertilisation (dpf); (2) just before the start of hatching, 57 dpf; (3) just after completion of hatching, 78 dpf; or (4) 20 days after hatching, 98 dpf. All treatments were maintained at 18°C until 63 days after emergence of alevins. Raising the temperature early in development reduced survival, and the survival rate in treatment 1 fell below 5% at 105 dpf. Observation of gonads at 335 to 456 dpf and 733 dpf revealed that 12 of 14 fish (85.7%) exposed to high temperature on and after 57 dpf exhibited sex reversal from the genetic female to the phenotypic male. Sockeye salmon therefore proved to exhibit thermolability in phenotypic expression of sex, and the temperature-sensitive window was in the early life stages on and after 57 dpf, which appears to conform with the exogenous androgen-sensitive window. This new technique of temperature control could contribute to producing all-female populations of this species in a safe, simple, environmental friendly, and acceptable manner.

Azuma, T (Natl Res Inst Aquaculture, Nikko Branch, Chugushi 2482-3, Nikko, Tochigi 3211661, Japan. Email: azuma@fra.affrc.go.jp), Takeda, K., Doi, T., Muto, K., Akutsu, M., Sawada, M. and Adachi, S. (2004). The influence of temperature on sex determination in sockeye salmon *Oncorhynchus nerka*. *Aquaculture* 234: 461-473.

17. Review of interactions between wild and escaped farm salmon

The high level of escapes from Atlantic salmon farms, up to two million fishes per year in the North Atlantic, has raised concern about the potential impact on wild populations. This report of a two-generation experiment examined the estimated lifetime successes, relative to wild natives, of farm, F1 and F2 hybrids, and BC1 backcrosses to wild and farm salmon. Offspring of farm and ‘hybrids’ (i.e. all F1, F2, and BC groups) showed reduced survival compared with wild salmon, but grew faster as juveniles and displaced wild parr, which were significantly smaller. Where suitable habitat for these emigrant parr is absent, this competition would result in reduced wild smolt production. In the experimental conditions, where emigrants survived downstream, the relative estimated lifetime success ranged from 2% (farm) to 89% (BC, wild) of that of wild salmon, indicating additive genetic variation for survival. Wild salmon primarily returned to fresh water after one sea winter (1 SW) but farm and 'hybrids' produced proportionately more 2SW salmon. However, lower overall survival means that this would result in reduced recruitment despite increased 2SW fecundity. The study therefore demonstrates that interaction of farm with wild salmon results in lowered fitness, with repeated escapes potentially causing cumulative fitness depression and an extinction vortex in vulnerable populations.

McGinnity, P., Prodohl, P., Ferguson, K (Queens Univ Belfast, Sch Biol & Biochem, Belfast BT7 1NN,Antrim, North Ireland. Email: a.ferguson@qub.ac.uk), Hynes, R., O'Maoileidigh, N., Baker, N., Cotter, D., O'Hea, B., Cooke, D., Rogan, G., Taggart, J. and Cross, T. (2003). Fitness reduction and potential extinction of wild populations of Atlantic salmon, *Salmo salar*, as a result of interactions with escaped farm salmon. *Proceedings of the Royal Society of London Series B-Biological Sciences,* 270: 2443-2450.

18. Triploid type influences mortality from bacterial gill disease

In this study, three types of triploid rainbow trout were induced, either by retention of the second polar body (RSP) or by cross fertilisation between tetraploids and diploids (4n female x 2n male and 2n female x 4n male). Significant differences were observed in mortality following bacterial gill disease (BGD) infection. The tolerance to BGD in (4n female x 2n male) was higher than those in (RSP) and (2n female x 4n male). The haemoglobin concentrations differed between the strains, with (4n female x 2n male) being higher than the other two types, although no difference was observed in the hypoxic tolerance between the three strains. Since it is known that fish with BGD die from asphyxiation and mortality is affected by the environmental oxygen level, haemoglobin concentration of fish could be closely associated with the tolerance against BGD.

Yamamoto, A (Kagoshima Univ, Fac Fisheries Dept Aquat Resource sci, Kagoshima 8600056, Japan. Email: ayam@fish.kagoshima-u.ac.jp), Nagura, J. and Iida, T. (2003). Influence of hemoglobin concentration on tolerance to bacterial gill disease in rainbow trout. *Fish Pathology,* 38: 99-103.

19. Clove oil study 1

This study assessed the effectiveness of the anaesthetic clove oil (eugenol) at reducing a stress response to handling in rainbow trout. Clove oil (60 mg l^{-1}) was compared to MS-222 (tricaine methanesulphonate-60 mg l^{-1}) by measuring blood chemistry to quantify the physiological stress response to handling. Few differences were apparent in the blood chemistry between fish treated with either clove oil or MS-222. However, clove oil was more effective at reducing the short-term stress response induced by handling and blood sampling, and was therefore recommended as an alternative fish anaesthetic.

Wagner, G.N. (Univ British Columbia, Dept Forest Sci, 3022-2424 Main Mall, Vancouver, BC V6T 1Z4, Canada. Email: glennw@interchange.ubc.ca). Singer, T.D. and McKinley, R.S. (2003). The ability of clove oil and MS-222 to minimize handling stress in rainbow trout (*Oncorhynchus mykiss* Walbaum). *Aquaculture Research,* 34: 1139-1146.

20. Clove oil study 2

This study evaluated the effects of clove oil dose (25, 50, and 100 mg l^{-1}) and temperature (11, 15, 20°C) on anaesthesia in steelhead *Oncorhynchus mykiss* fry (0.18 g). Induction time decreased significantly with increasing temperature and dose. Recovery time after removal from anaesthesia decreased significantly with increasing temperature. Mortality at 24 h post-anaesthesia increased significantly with increasing temperature and dose. The study concludes that although clove oil appears to be an effective general anaesthetic for salmonid fry, care must be taken in determining the appropriate dose to minimise temperature-associated mortality.

Woolsey, J., Holcomb, M. and Ingermann, R.L. (Univ Idaho, Dept Biol Sci, Moscow, ID 83844, USA. Email: rolfi@uidaho.edu). (2004). Effect of temperature on clove oil anesthesia in steelhead fry. *North American Journal of Aquaculture,* 66: 35-41.

21. Clove oil study 3

This study examined the potential use of clove oil as an anaesthetic for Atlantic salmon, brown trout, rainbow trout, whitefish, perch and roach at 5, 10, 15 and 20°C using three anaesthetic concentrations (varying from 20 to 200 mg l^{-1}) at each temperature. Temperature and clove oil concentration affected both induction and recovery times. There were marked differences between species in sensitivity to clove oil. The study supported previous findings regarding the ease of use and efficacy of clove oil, but some disadvantages were found. Slow recovery was found in roach and Atlantic salmon, and mortality was recorded in perch and whitefish.

Hoskonen, P. and Pirhonen, J. (Univ Jyvaskyla, Dept Biol & Environm Sci, POB 35, FIN-40014 Jyvaskyla, Finland. Email: jpirhon@bytl.jyu.fi). (2004). Temperature effects on anaesthesia with clove oil in six temperate-zone fishes. *Journal of Fish Biology,* 64: 1136-1142.

22. Vaccination reduced feed intake and growth of salmon

Feed intake is generally considered to be a reliable criterion to evaluate health and welfare in farmed fish. This study investigated the effects of anaesthetisation and vaccination on feed intake and growth of Atlantic salmon, using a feed waste collection system that enabled daily feed intake to be measured without disturbing the fish. The study demonstrated that benzocaine anaesthetisation, irrespective of short or long duration, had a minor, not significant, short-term effect on feed intake. However, fish vaccinated with an oil adjuvant vaccine, had a significantly reduced feed intake in the 12 day period after vaccination. A tendency of lower feed intake persisted until 25 days after treatment. The reduced feed intake of the vaccinated groups was reflected in approximately 20% reduced growth at the end of the experiment, 32 days after treatment. The results show that use of feed waste collection system can be used to evaluate the side effects of vaccination and the welfare of farmed fish.

Sorum, U. (Norwegian Inst Fisheries & Aquaculture, N-9291 Tromso, Norway. Email: unn.sorum@flskeriforskning.no) and Damsgard, B. (2004). Effects of anaesthetisation and vaccination on feed intake and growth in Atlantic salmon (*Salmo salar* L.). *Aquaculture,* 232: 333-341.

23. Dietary carotenoids enhance trout immunity

This study examined the effects of carotenoids from natural sources on the non-specific defence mechanisms of rainbow trout. Fish were fed for 9 weeks on four diets containing either beta-carotene or astaxanthin at 100 and 200 mg kg^{-1} from a marine algae (*Dunaliella salina*) and red yeast (*Phaffia rhodozyma*) and a control diet containing no supplemented carotenoids. Specific growth rate and feed: weight gain ratio were not affected by dietary treatment. Of the humoral immune factors, serum alternative complement activity increased significantly in all carotenoid supplemented groups in comparison to the control; serum lysozyme activity increased in the *Dunaliella* group but not in the *Phaffia* group, and plasma total immunoglobulin levels were not altered by the feeding treatments. Of the cellular responses, phagocytosis was significantly higher in all supplemented groups than the controls, but the superoxide anion production from the head kidney remained unchanged. These findings demonstrate that dietary carotenoids can modulate some of the innate defence mechanisms in rainbow trout.

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24. Effects of vitamin E on immune response of trout

This study was designed to examine the effects of dietary vitamin E (VE) on modulation of immune responses when supplied with two levels of n-3 highly unsaturated fatty acids (n-3 HUFA) in rainbow trout. Six diets were prepared containing three levels of dietary VE (0, 100 or 1000 mg alpha-tocopheryl acetate kg^{-1} diet) and n-3 HUFA either at 20 or 48% of dietary lipid. The diets were fed to rainbow trout for 15 weeks. Both humoral and cellular immune functions deteriorated in fish fed VE deficient diets whereas improvement in most of the parameters corresponded to its supplementation. However, the higher dose of dietary VE did not substantially enhance the responses assayed compared to the 100 mg dose. Besides clearly indicating the role of VE in maintaining the immune functions in fish in relation to dietary n-3 HUFA, this study has revealed that optimum health benefits could be achieved when VE is maintained slightly above the levels generally recommended for normal growth.

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25. Probiotic bacteria enhance trout immunity

This study assessed the immune enhancement of fish by a lactic acid bacterium (LAB) *Lactobacillus rhamnosus*. The bacterium was mixed with the feed at five different doses and fed to rainbow trout for two weeks and the feed was then changed to un-supplemented diet. Blood and mucus samples were taken to analyse immune response parameters from the onset of feeding supplemented diets and at 1, 2, 3 and 4 weeks. While being fed the supplemented feed, LAB were present in the fish intestine and in the tank water in high numbers. However, within one week of the change to the non-supplemented feed, LAB disappeared from the intestine, skin mucus and tank water. In comparison to untreated control fish, various immune responses (respiratory burst activity of blood cells, serum-mediated killing of *Escherichia coli*, serum immunoglobulin levels) were raised in the LAB treatment groups, showing that rainbow trout immune parameters were enhanced by using probiotic bacteria.

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