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TROUT PRODUCTION

2000 SURVEY OF TROUT PRODUCTION IN ENGLAND AND WALES

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During 2001, the inspection and monitoring programme of salmonid farms, undertaken on behalf of MAFF/ DEFRA and the Agriculture Department of the National Assembly for Wales under the European Council Directive 91/67/EC, was carried out. Due to the outbreak of Foot and Mouth Disease across most of the country the Fish Health Inspectors were unable to gain access to all sites in time to produce this report at the usual time. However, after an extensive effort by the Fish Health Inspectors and the co-operation of the industry, the production details were completed in the second half of the year once the Foot and Mouth Disease situation had passed. A total of 293 registered salmonid farm sites were visited during 2001. Of this total there were 19 sites with no sales of fish during 2000 but continued to hold stock and 5 sites failed to provide data or whose ownership changed and therefore no accurate data was available. In addition during the period 13 new farms were registered and 31 sites ceased trading and were deregistered during the year, though some of these still reported production. The data included in this report and provided by the site owners therefore represents the production from a final total of 269 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. However, the Fish Health Inspectorate has altered the collection areas in order to correspond to current Environment Agency areas. This means that, in a change from previous years, the Wessex area has been merged with the South West region to form a single region called SouthWest and Yorkshire and Northumbria have been merged to form the North East region. Sites are classified into one of four different categories as follows:

1) Sites that did not produce any rainbow trout during 2000

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 2000 was 5757 tonnes from 100 farm sites. This figure is lower than that for 1999 (6710 tonnes). A total of 185 farms produced rainbow trout for restocking fisheries or ongrowing purposes, this was an increase of 4 sites on the 1999 numbers. These sites together produced 3427 tonnes during 2000, of which 3015 tonnes were restocking trout and 412 tonnes were fingerlings or yearlings for ongrowing. This figure represents a 6% increase on the total restocking and ongrowing production recorded for 1999 (3224 tonnes).

Table 1. 2000 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	2	7	4	14	28	485	0
North East	5	6	14	9	34	959	331	7,296
North West	2	3	6	10	21	120	131	75
Midlands	2	0	12	2	16	9	201	130
Southern	6	5	15	5	31	1,743	215	337
South West	4	14	35	20	73	1,909	1,560	11,115
Thames	1	2	10	8	21	573	290	390
Welsh	2	4	22	6	34	416	216	3,705
Totals	23	36	121	64	244	5,757	3,427	23,047

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

Environment Agency Area	Production according to farm output category (tonnes)				
	0-10	11-50	51-100	101-200	>201
Anglian	25 (7)	104 (4)	145 (2)	0 (0)	273 (1)
North East	42 (18)	238 (9)	238 (4)	456 (4)	498 (2)
North West	31 (13)	120 (5)	122 (2)	0 (0)	0 (0)
Midlands	47 (12)	123 (5)	61 (1)	0 (0)	0 (0)
Southern	54 (17)	173 (9)	51 (1)	200 (1)	1,528 (4)
South West	101 (42)	762 (26)	805 (11)	974 (7)	907 (3)
Thames	41 (10)	240 (8)	93 (1)	301 (2)	228.9 (1)
Welsh	76 (31)	144 (7)	324 (4)	130 (1)	0 (0)
Totals	416 (150)	1,904 (73)	1,838 (26)	2,061 (15)	3,435 (11)
% Total Production	4.3	19.7	19.0	21.3	35.6
% Farms involved	54.5	26.5	9.5	5.5	4.0

The overall rainbow trout production (combining table and restocking/ongrowing figures) for England and Wales in 2000 was 9184 tonnes, a decrease of around 750 tonnes on 1999 production. This demonstrates an 8% loss in total production in the industry.

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

Just over 54% of the trout farms in England and Wales are in the 0-10 tonnes category but their combined output only accounts for 4.3% of total production, a slight rise on last years figures. The numbers of registered small farms during 2000 has increased by 49 from 1999, while the numbers of slightly larger (51-100 tonne) farms and the largest farms (>201 tonnes) has remained roughly the same. The biggest farms (those producing over 200 tonnes annually) account for over 35% of total trout production but form 4% of the total number of trout farms in England and Wales. The South West area contains the highest number of farms (89) and produces the most trout of any region (Almost 37%) in England and Wales.

Production of other farmed salmonids

The 2000 production information for brown trout and Atlantic salmon is summarised in Table 3. Of the 269 registered salmonid farms producing fish during 2000,118 sites produced brown trout in addition to rainbow trout and 17 sites produced brown trout only (a total of 135 sites – an increase of 54 sites from 1999). 12 Farms produced both trout and atlantic salmon and 14 sites concentrated on producing salmon alone, 7 farms failed to produce any Salmon. Total production of

Table 3. 2000 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	6	5	33	0	2	1	0	260
North East	18	14	178	168	3	0	840	0
North West	9	3	22	1	5	0	1,400	4,060
Midlands	13	8	17	85	2	0	1	18
Southern	24	19	44	27	2	0	162	0
South West	35	20	56	753	0	0	0	0
Thames	11	10	37	8	1	0	23	0
Welsh	20	13	26	51	5	0	207	8,444
Totals	136	92	413	1,092	20	1	2,631	12,782

brown trout in England and Wales has increased to 413 tonnes after a fall in production for 1999 (311 tonnes). Only 3 sites recorded brook trout (*Salvelinus fontalinus*) production in 2000 – 0.3 tonnes were produced for the restocking market, a decrease from last years level of 0.7 tonnes, 3 tonnes was also recorded as being produced for the table market and none were recorded as being produced for ongrowing purposes. Three sites continue to trial the production of Arctic Char, however, the production of this species is still not significant (0.6 tonnes to the Ongrowing trade and 0.06 tonnes for the table market).

Commercial units that supply farms in Scotland produced the majority of salmon smolts. A total of 1.8 million smolts were produced from seven sites, a decrease of 1.4 million from last year. Seven commercial sites also produced 231 thousand salmon parr. In addition, seven Environment Agency salmonid rearing sites operated during 2000 to produce fry and juvenile salmon for specific river stock enhancement programmes. These sites together produced 98,746 salmon smolts, just over ½ million salmon parr, ¼ million salmon fry and 86,073 sea trout fry. The numbers of salmon smolts produced by the EA sites has increased while the numbers of fry produced has slightly decreased from last years total, the numbers of sea trout has increased by 17% on last years numbers. The changes in production from these sites suggests that the emphasis of salmon stock management is moving towards the use of younger fish while maintaining the emphasis on habitat improvement programmes. The emphasis on brown trout stock management appears to have moved towards enhancing the stock of juvenile fish in the river systems.

Ova production

The recorded figures for salmonid ova produced over the period running from late 2000 through to early 2001 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 21 million eggs, of which ¼ million were sold to other sites. This reduction in movements to other farms was largely a consequence of the disruption to trade caused by the restrictions in place for the Foot & Mouth Disease outbreak. These figures are a reduction of just over 20.5% from the 1999/2000 season (26.3 million eggs) this is the third year in a row that such a decline has been noted. Mixed-sex rainbow trout egg production has returned to the 1998/99 levels (just over 2.4 million from 6 million in 1999/2000). The recorded production of rainbow trout triploid eggs was almost 7.3 million, which is an increase from the 1999/2000 level of 4.9 million, it would appear that the production of mixed sex eggs has been replaced by the production of triploid eggs.

The majority of brown trout ova produced were mixed-sex and production totalled just over 3.4 million ova, a significant decrease on last years figures, of this total just under 350,000 were sold to other sites. A total of 745,000 all-female brown trout ova were produced, a 50% increase on the 1999 levels. Triploid ova production was recorded as 535,000 – an increase of just over 6% on the last year's figure. This represents a decrease of just over 50% in the overall production of brown trout eggs from last year's level.

54,500 Salmon eggs were produced by commercial salmon rearing sites, this is a significant decrease from 1999 levels. A further 1.5 million eggs were produced for Environment Agency stock enhancement programmes, an increase of around 72% from last years levels. In addition, 65,000 eggs from salmon broodstock obtained from the River Lune were laid down by commercial hatcheries, in co-operation with the Environment Agency, and reared to produce parr for local stock enhancement schemes. This is the same number as in 1999.

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

Table 4. 2000/2001 eyed ova production from sites holding broodstock salmonids in England and Wales (not including sea trout and salmon produced from wild broodstock by the EA)

Environment Agency Area	Rainbow trout			Brown trout			Salmon
	All Females (thousands)	Mixed Sex (thousands)	Triploid (thousands)	All Females (thousands)	Mixed Sex (thousands)	Triploid (thousands)	Mixed Sex (thousands)
Anglian	150	100	0	0	85	0	40
North East	10,700	35	1,156	32	1,242	0	0
North West	130	19	0	0	300	0	0
Midlands	200	138	50	0	145	0	0
Southern	223	3	650	30	268	81	0
South West	8,312	850	2,978	133	915	454	0
Thames	1,260	7	2,500	550	325	0	0
Welsh	30	1,279	0	0	175	0	14
Totals	21,005	2,431	7,334	745	3,455	535	54

2000 SURVEY OF TROUT PRODUCTION IN SCOTLAND

Data supplied from SERAD (Rural Affairs Department of the Scottish Executive) Annual Production Survey, 2000.

Rainbow trout were produced from 63 sites involving 54 companies with an overall production of 5,154 tonnes in 2000 (5,834 tonnes in 1999) a decrease of 680 tonnes on the previous year (a decrease of almost 12%). Trends in production over the last 10 years are given in Table 1 below.

Table production

Table 2 gives trends in production for table fish over the past 7 years. Production in 2000 amounted to 4,311 tonnes representing a decrease of 546 tonnes (11%) on the previous year and accounting for 83% of total production.

Fish weighing up to 450 g made up the bulk of table production representing 69% of total production.

Restocking production

Table 3 provides production data for the restocking trade for the last 7 years. Production for restocking decreased by 136 tonnes (14%) to 843 tonnes representing 16% of the total production (17% in 1999).

Escapes

There were six escape events reported from rainbow trout farms in Scotland in 2000, resulting in an estimated total loss of 63,440 fish.

Table 1. Total production for the period 1991-2000

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Tonnes	3,334	3,953	4,023	4,263	4,683	4,630	4,653	4,913	5,834	5,154

Table 2. Production of table fish for the period 1994-2000

Year	<450 g < 1 lb	450-900 g 1-2 lb	>900g >2 lb	Total tonnes
1994	2,376	288	1,038	3,702
1995	2,736	199	1,149	4,084
1996	2,701	181	1,002	3,884
1997	2,646	104	1,098	3,848
1998	3,009	173	887	4,069
1999	3,151	144	1,562	4,857
2000	3,005	203	1,103	4,311

Table 3. Production for the restocking trade in 1994-2000

Year	<450 g < 1 lb	450-900 g 1-2 lb	>900 g >2 lb	Total tonnes
1994	125	337	99	561
1995	107	411	81	599
1996	188	484	74	746
1997	97	589	119	805
1998	69	538	237	844
1999	236	552	187	977
2000	41	609	193	843

Method of Production

Table 4 provides a breakdown of trout farms by system and scale of production. Freshwater production remained relatively stable at 4,370 tonnes (85% of the total) while seawater production decreased by 73% on the previous year to 784 tonnes (15% of the total).

Production and manpower by region

The regional production and manpower information shown in Table 5 relate to Scottish Local Government Regions following their reorganization in 1996. These are shown in Figure 1.

Productivity ranged from 22.9 to 43.5 tonnes/person between production areas, being greatest in the West and least in the Northern and Eastern areas.

Mean productivity in tonnes/person for the 4 production areas reached 29.7 tonnes in 2000 representing a decrease of 2.4 tonnes on the previous year. Over the same period staff employed decreased by 9 to 168.

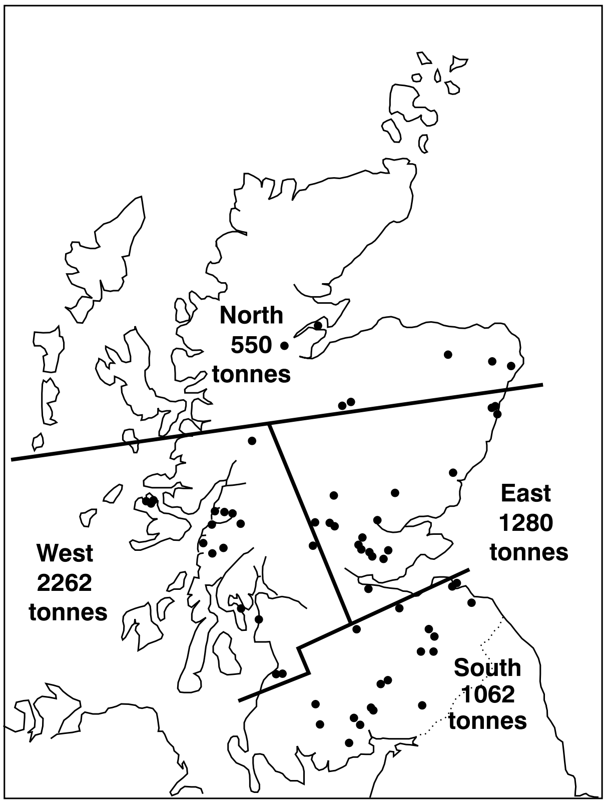

Figure 1. Map of Scotland showing total production in the four trout areas for 2000 and distribution of active sites

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

Production method	Production grouping (tonnes) in 2000					Total tonnage	Total no.of sites	% contribution
	<10	10-25	26-50	51-100	>100			
FW cages	0	2	1	0	6	2,258	9	44.0
FW ponds & raceways	3	6	3	6	7	1,972	25	38.0
FW tanks & hatcheries	3	2	1	1	0	140	7	3.0
SW cages	0	0	0	0	3	784	3	15.0
SW tanks	0	0	0	0	0	0	1	0.0
Total	6	10	5	7	16	5,154	44	100

Table 5. Rainbow trout production and staffing by area in 2000

Area	No. of sites	Production			Mean tonnes/ sites	Staffing			Productivity tonnes/ person
		Table	Restocking	Total		F/T	P/T	Total	
North	7	414	136	550	78.6	16	8	24	22.9
East	19	975	305	1,280	67.4	40	16	56	22.9
West	17	2,134	128	2,262	133.1	39	13	52	43.5
South	20	788	274	1,062	53.1	26	10	36	29.5
All	63	4,311	843	5,154	81.8	121	47	168	29.7

Other species

Other species farmed in Scotland together with the production figures for 2000 and estimates for 2001 are given in Table 6.

Table 6. Production of other species in tonnes for 2000 and estimated production for 2001

Species	Production 2000	Estimated production 2001
Atlantic salmon	128,595	158,479
Arctic char	7	16
Brown trout/sea trout	138	191.5
Cod	15.7	41.0
Halibut	4.5	189

Ova production

The number of rainbow trout eyed ova laid down for hatching from home-produced stock, from other sources within Great Britain and from foreign imports are given in Table 7 for the period 1993 to 2000. The proportion of ova laid down from GB broodstock increased to 2.3 million representing nearly 11% of the total. The total number of eyed-ova laid down increased by over 2.3 million (12.3%) on the 1999 figure.

Type of ova

Details of the number and type of ova laid down for hatching are given in Table 8. The preference for all female diploid stock was again evident, accounting for 82% of all ova laid down. Triploid ova decreased for the first time in 4 years to 6% of the total, while mixed sex ova showed a five-fold increase on the previous year.

Table 7. Number and sources of ova laid down for hatching in 1993-2000

Year	Own stock	Other GB Stock	Total GB	Total foreign	Grand total	% GB
1993	1,830,000	405,000	2,235,000	17,509,000	19,744,000	11.3
1994	479,000	625,000	1,104,000	18,500,000	19,604,000	5.6
1995	165,000	360,000	525,000	20,310,000	20,835,000	2.5
1996	420,000	988,000	1,408,000	21,270,000	22,678,000	6.2
1997	1,232,000	837,000	2,069,000	21,434,000	23,503,000	8.8
1998	2,559,000	60,000	2,619,000	22,623,000	25,242,000	10.4
1999	878,000	392,000	1,270,000	17,361,000	18,631,000	7.0
2000	1,397,000	900,000	2,297,000	18,686,000	20,983,000	10.9

Table 8. Number and proportions (%) of ova types laid down for hatching in 1993-2000

Year	Total ova	All female diploid Nos. (%)	Triploid Nos. (%)	Mixed sex diploid Nos. (%)
1993	19,744,000	17,261,000 (87)	1,396,000 (7)	1,087,000 (6)
1994	19,604,000	18,105,000 (92)	1,134,000 (6)	365,000 (2)
1995	20,835,000	19,546,000 (94)	1,170,000 (6)	119,000 (+)
1996	22,678,000	21,308,000 (94)	935,000 (4)	435,000 (2)
1997	23,503,000	21,118,000 (90)	1,386,000 (6)	1,000,000 (4)
1998	25,242,000	23,222,000 (92)	1,515,000 (6)	504,000 (2)
1999	18,633,000	16,324,000 (88)	1,853,000 (10)	456,000 (2)
2000	20,979,000	17,264,000 (82)	1,202,000 (6)	2,513,000 (12)

2000 SURVEY OF TROUT PRODUCTION IN NORTHERN IRELAND

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

200 tonnes of rainbow trout and 250 tonnes of brown trout were produced for restocking. Ova and fry/ fingerlings surplus to requirements are exported.

Table 1. Rainbow trout table production

Production	No. of sites	Total production (tonnes)	Number employed (including hatcheries)		Sites not producing
			Full-time	Part-time	
0-9 tonnes	8	75	8	5	-
10-24 tonnes	9	240	12	9	2
25-49 tonnes	5	222	7	5	0
50-99 tonnes	5	470	6	4	-
100-199 tonnes	3	260	5	3	-
Total	30	1,267	38	26	2

Table 2. Ova production

No. of Hatcheries	Rainbow trout	Brown trout	Migratory trout
7	14,000,000	-	-
2	-	1,500,000	-
7	-	-	250,000

SUMMARY OF UK RAINBOW TROUT PRODUCTION IN 2000

Details of rainbow trout production both for the table trade and restocking are given in Table 1 below for England and Wales, Scotland and Northern Ireland.

Total production in 2000 amounted to 15,805 tonnes (17,185 tonnes in 1999) representing a decrease of 1,380 tonnes (8%) on the previous year.

Table 1. UK Rainbow trout production for 2000

	Production in tonnes		
	Table	Restocking	Totals
England and Wales	5,757 (62.7%)	3,427 (37.3%)	9,184
Scotland	4,311 (83.6%)	843 (16.4%)	5,154
Northern Ireland	1,267 (86.4%)	200 (13.6%)	1,467
Totals	11,335 (71.7%)	4,470 (28.3%)	15,805

RAINBOW TROUT EGG IMPORTS IN 2000

England and Wales

Imports of rainbow trout eggs into England and Wales during 2000 totalled 50.8 million (Table 1) This represents a significant increase on the number imported the previous year (30.4 million).

Table 1. Summary of rainbow trout eggs imported into England and Wales by month in 2000

Month	Northern Ireland	Isle of Man	Denmark	SouthAfrica	Total
January		965,000			965,000
February		1,085,000			1,085,000
March		1,800,000	3,350,000		5,150,000
April		500,000	1,195,000		1,695,000
May		425,000	1,150,000		1,575,000
June		30,000		7,540,000	7,570,000
July	1,008,000			13,705,000	14,713,000
August	100,000			7,362,500	7,462,500
September	520,000			3,000,000	3,520,000
October		1,005,000			1,005,000
November		2,580,000	400,000		2,980,000
December	100,000	2,375,000	600,000		3,075,000
Total	1,728,000	10,765,000	6,695,000	31,607,500	50,795,500
Total %	3.4	21.2	13.2	62.2	100

Scotland

The number and source of imported rainbow trout ova for 2000 are given in Table 2. The total imported - over 18.90 million represents an increase of 0.67 million eggs over the 1999 figure (18.24 m) Denmark, the Isle of Man and Northern Ireland accounted for over 11.1 million eggs, representing 59% of ova imports. Imports from South Africa amounted to nearly 7.8 million, an increase of nearly 1.7 million on the previous year, representing 41% of the total imports.

Table 2. Number and source of trout ova imported into Scotland plus number of consignments (in brackets) by month in 2000

Month	Northern Ireland	Isle of Man	Denmark	SouthAfrica	Total
January	210,000 (1)	1,400,000 (4)	-	-	1,610,000 (5)
February	100,000 (1)	480,000 (2)	1,200,000 (2)	-	1,780,000 (5)
March	-	-	2,450,000 (4)	-	2,450,000 (4)
April	-	50,000 (1)	200,000 (1)	-	250,000 (2)
May	-	5,000 (1)	150,000 (1)	300,000 (1)	455,000 (3)
June	5,000 (1)	-	-	700,000 (3)	705,000 (4)
July	-	-	-	4,050,000 (8)	4,050,000 (8)
August	-	-	-	2,312,000 (5)	2,312,000 (5)
September	500,000 (1)	-	-	400,000 (1)	900,000 (2)
October	270,000 (2)	50,000 (1)	-	-	320,000 (3)
November	-	1,720,000 (3)	-	-	1,720,000 (3)
December	-	2,137,000 (4)	225,000 (1)	-	2,362,000 (5)
Totals	1,085,000	5,842,000	4,225,000	7,762,000	18,914,000
Consignments	6	16	9	18	49

Total egg imports

Overall the total number of eggs imported into the UK from foreign sources in 2000 amounted to over 69 million (46 million in 1999) representing a significant increase of 23 million (50%) on the previous year.

EUROPEAN TROUT PRODUCTION

The latest production figures for rainbow trout released by the Federation of European Aquaculture Producers (FEAP) on its website (http://www.feap.org/countries/countries.htm) are given in Table l below for 21 European countries. The figures for large rainbow trout are for fish in excess of l kilo in weight and include both fresh-water and sea-grown (salmon trout) production.

Total European production for 2000 is estimated to be over 323,700 tonnes with Norway as the leading producer at 60,000 tonnes followed by France and Italy with 47,500 and 44,300 tonnes respectively. UK production, estimated at 17,800 tonnes in 2000, ranked seventh in the league of European trout producing countries.

Table 1. European production of portion-sized (P) and large (L) rainbow trout for the period 1995-2000

Country	1995		1996		1997		1998		1999		2000	
Austria	3,500	P	3,000	P	3,000	P	3,000	P	3,000	P	3,000	P
	350	L	400	L	400	L	400	L	400	L	400	L
Belgium/Luxemberg	600	P	700	P	700	P	700	P	700	P	700	P
	200	L	100	L	120	L	100	L	100	L	100	L
Cyprus	98	P	110	P	105	P	90	P	90	P	-	
Czech Republic	645	P	647	P	499	P	554	P	723	P	700	P
Denmark	34,000	P	30,000	P	29,300	P	32,000	P	30,000	P	30,000	P
	7,000	L	7,000	L	7,000	L	7,500	L	7,500	L	7,500	L
Faroe Islands	452	L	63	L	100	L	0	L				
Finland	17,300	L	18,000	L	16,500	L	16,500	L	15,300	L	15,200	L
France	42,000	P	48,000	P	42,000	P	42,500	P	37,000	P	37,500	P
	8,000	L	8,000	L	8,000	L	8,000	L	8,000	L	10,000	L
Germany	23,500	P	23,500	P	23,500	P	23,500	P	23,500	P	23,500	P
	1,500	L	1,500	L	1,500	L	1,500	L				
Greece	2,455	P	2,500	P	2,322	P	2,300	P	2,500	P	2,800	P
Iceland	379	L	728	L	580	L	300	L	100	L	100	L
Ireland	1,000	P	1,000	P	1,000	P	1,000	P	1,000	P	1,000	P
	300	L	300	L	300	L	300	L	1,100	L	1,200	L
Italy	44,500	P	48,500	P	50,000	P	47,000	P	43,000	P	43,500	P
	500	L	500	L	1,000	L	1,000	L	800	L	800	L
Netherlands	200	P	200	P	200	P	200	P	10	P	10	P
Norway	13,000	L	20,000	L	34,000	L	47,000	L	50,000	L	60,000	L
Poland	4,679	P	5,800	P	6,500	P	9,000	P	9,000	P	11,000	P
Portugal	3,000	P	1,500	P	1,500	P	1,500	P	1,500	P	1,500	P
Spain	18,000	P	24,000	P	25,000	P	26,000	P	27,000	P	27,000	P
	750	L	1,000	L	850	L	700	L	700	L	800	L
Sweden	174	P	150	P	200	P	200	P				
	5,772	L	6,000	L	4,875	L	6,500	L	7,250	L	7,000	L
Turkey	6,977	P	8,000	P	18,075	P	20,125	P	17,150	P	18,220	P
					2,000	L	2,500	L	2,200	L	2,400	L
UK	10,689	P	13,500	P	14,300	P	14,875	P	17,200	P	17,200	P
	2,468	L	1,350	L	800	L	950	L	600	L	600	L
Totals portion size	196,017		211,107		218,201		224,544		213,373		217,630	
Totals large size	57,971		64,941		78,025		93,250		94,050		106,100	
Grand total	**253,988**		**276,048**		**296,226**		**317,794**		**307,423**		**323,730**	

ARTICLES

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

Dick Lincoln, CEFAS, Pakefield Road, Lowestoft, Suffolk NR33 0HT

Introduction

A total of 17 papers were presented over the two days of this conference covering a broad range of subjects. These included nutrition (vegetable oils), genetic selection, food safety, algal taint and humane slaughter but with a heavy emphasis on fish health and legislation (6 papers). As usual, my report is divided into 2 parts with the following covering the first day's proceedings, the remainder appearing in the following July issue.

The food industry under attack

Barrie Gardner of Hydro Seafood, Norway opened with a personal view, gained over 30 years experience of the food industry, of how food scares develop, and then went on to describe the counter measures that can be employed, the role of quality systems, food safety and the retailers perspective.

His introduction described the nightmare the food industry is presently undergoing listing *E. coli*, sea lice, environmentalists, exchange rates, GMOs, BSE, F and M and disease legislation as just a few of the problems. Typically the chain of events start with facts that come in (typically scientific or hard facts), interest groups then work up a story line and journalists in the media apply spin. Articles are published and the media at large put their interpretation on the facts leading to a change in behaviour. Re-iteration of the story then kicks off a food scare followed by Government intervention and changes in legislation and food specification. This, he said, had led to two thirds of the German population not eating beef and three out of ten lamb consumers thinking it was infected with Foot and Mouth disease. Another example was the scare over genetically modified oil seed rape which finally ended in crop destruction by environmentalists in 1998 and the prosecution of Monsanto in the UK the following year. He blamed the company for not carrying out a PR exercise before the trials commenced and the prospects for this technology now seemed bleak. He considered the trout sector could be the next victim, although fortunately this was not the most exposed of industries and there were opportunities to employ counter strategies that would require strong industry leadership.

There were a number of ways in which the impact of food scare can be neutralised. This may involve the careful introduction and presentation of scientific information both from companies and the industry, educating journalists and food writers, setting up visitor centres and PR programmes, lobbying government and establishing joint strategies with retailers. The role of quality systems (HACCPS, Iso 9002, Iso 14001), accreditation (EFSIS) and certification schemes (SQT – we state what we do and we do what we state) and food traceability were all important in enhancing public confidence and allaying food scares.

Both fisheries and aquaculture provide an important source of food and employment and must be conducted in a responsible, way he said. Food safety was an intrinsic part of food quality and involved accountability, trust, reliability and integrity. Quality concerned meeting expectations and specifications and was often associated with emotions. It was important for industry to define, measure, manage and improve quality criteria. Consumer trust should not be based on information about the food supplier alone, but from the fish farmer, processor and retailer. Food safety required proactive measures involving public relations with the consumer and the trade, for example Freedom Foods. Only by understanding how previous issues develop will it be possible to handle problems in the future.

Concluding his talk he listed PCBs, listeria, dioxins, antibiotics, GMOs and salmonella as the main issues confronting aquaculture in the future. Handling these would require leadership, excellence and professional PR.

European salmon marketing survey

David Nickell, a one time trout farmer and currently European aquaculture specialist with Roche Vitamins (UK) Ltd summarised the key points of a consumer survey of salmon markets in Europe and its consequences for the industry. The survey, which was commissioned by the International Salmon Farmers Association and supported by Roche was carried out by GIRA Strategic Marketing Research, a company based in France. Salmon markets in France, UK and Germany (which collectively account for two thirds of salmon consumption in the EU) were surveyed at the consumer level with the objective of increasing the total market value by increasing volume without lowering margins.

Street interviews, carried out with 300 salmon consumers in each country revealed the requirements for different meals and their solutions, and how particular meat products were conceived. This information generated a dynamic picture of which foods were declining, expanding or static in terms of consumption.

Consumers perceived salmon in terms of a muscle rather than a meat or fish, a feminine product that was pure and unpolluted, all elements that were highly valued. The concept of salmon farming was not understood by consumers in all countries and the method and type of farming was considered more important than its geographic origins. Both the frozen and fresh market was perceived as totally different from that of smoked salmon and further processed products. There was a strong demand for healthy products in the UK and fillets accounted for 58% of the fresh and frozen market, eaten mainly as an evening meal (75%). Consumption of prepared and processed products was increasing in both France and the UK mainly as a packed lunch in the latter. As a meal solution salmon was well regarded as a food in tune with present day ideologies but suffered from less product differentiation than competing food sectors. For example in the fresh and processed sectors there were 2 to 8 times more chicken products compared to salmon and 2 to 5 times more ham (smoked). Product differentiation relies, to a certain extent, on the consumer understanding the farming process. Although free-range and battery chickens is understood by everyone, this was not so for salmon farming and there was a requirement in all three countries to educate consumers with the facts. Nevertheless salmon enjoyed a very positive image with a huge potential in developing new products.

The survey, he said, had generated a large amount of information that could be used to tailor products to consumer demand. However, the salmon industry considered the report a bit too far down the line, at least 2 years off for many of the concepts raised. He considered all the information in the report was directly applicable to the trout industry.

State of the fish stocks

Richard Millner of CEFAS, Lowestoft gave an account of the state of the major fin fish stocks in the sea surrounding the UK. Following his introduction he described how the assessments were made and then surveyed a few of the major commercial stocks by species.

Stocks are built up through recruitment and growth and reduced by fishing mortality and disease. Unlike in aquaculture where there is close control over all aspects of production wild marine stocks are a common resource in which only control over the rate of harvesting is possible through fishing effort. He described the life history of the plaice, a commercially important flat fish. This species matures at three years of age, migrates to the spawning grounds, aided by tidal stream drift, and returns after spawning to the feeding grounds. The larvae drift in the surface currents where huge natural mortality takes place accounting for the variability in stock recruitment from year to year. Juveniles and large fish occur together and both get caught and although undersized fish are returned to the sea they are often damaged and do not survive.

In the assessment process the amount of fish landed and the number of boats fishing for each stock is required in addition to surveys carried out by research vessels. For each stock 400,000 fish are sampled each year for age determination by counting the annual growth rings on scales or ear stones. This information is then used to calculate how each stock is surviving. Similar data is collected by all national fishery laboratories and analysed and discussed at the annual working groups of the International Council for Exploration of the Sea (ICES) where the stock assessments are made. The information provides options to scientific and technical committees on fisheries within the European Community which is then discussed at the EC Council of Ministers. It is at this meeting that national quotas are determined for each species and where much haggling takes place.

Dr Millner then gave examples of stock abundance for some of the major commercial species in the North Sea. Cod stocks surveyed over the years 1996-1998 for 3, 4 and 5 year olds indicated that very few fish survived beyond age 4. Spawning recruitment over the period 1963-1999 had become progressively smaller and the stock was now considered outside safe biological limits and could collapse at any time. He said the poor recruitment figures are thought to be due to environmental change; a well documented relationship exists between year class strength and sea temperature in which better spawning takes place at lower temperatures. In cold winters cod usually spawned well but this did not happen any more due to substantially higher temperatures recorded for the North Sea over the last 10 years. Haddock stocks, which were still relatively high in the 1960s are now at historically low levels and a similar situation existed for plaice. The sand eel fishery for fish meal has expanded significantly since the 1960s and the stock goes up and down but remains relatively stable. However there has been pressure applied to reduce the catch because sand eels form the base of the food chain for many fish and birds.

He concluded with a table comparing the tonnage of fish landed and the amount farmed for 4 commercially important species for the year 2000. Farmed cod amounting to 75 tonnes represented an insignificant production but halibut at 482 tonnes and turbot at 5,393 tonnes represented 20.8 and 91.2% respectively of wild caught fish. On the other hand farmed sea bass totalling nearly 47,000 tonnes far outstripped the supply from the wild by a factor of 16 times. These figures gave cause for optimism in the future where increasing amounts of cultivated marine species may help reduce fishing pressure on wild fish stocks in the sea.

Vegetable oils in salmonid feeds

John Sargent of the Institute of Aquaculture, Stirling University, a specialist in the biochemistry and nutrition of lipids, summarised the current knowledge on the replacement of fish oils in salmonid feeds with vegetable oils and considered what implications this had both for the producer and consumer.

He began by explaining why alternatives are required. Fish production from capture fisheries that are required in fish meal manufacture are currently static or in decline at a time when the demand for fish meal and oil in aquaculture feeds continues to rise. It is estimated that 60% of global supplies of fish oil are now used in aquaculture mainly in salmon and trout production, rising to 90% by the year 2009. In addition pressure continues on manufacturers from environmental groups to use sustainable resources and EU restrictions on the level of dioxins and PCBs in animal feeds are being applied. These pollutants accumulate in fish in the wild and passed on in the feed to farmed fish which are now the principal source of dioxins. Inevitably fish oil prices must rise in the future and constitutes one of the biggest issues now facing feed manufacturers.

On a scientific and practical basis fish feeds must contain (a) proteins rich in essential amino acids in a form accepted and digested by fish and (b) oils that meet the requirements for the essential polyunsaturated fatty acids (PUFAs), namely 20:5n – 3 and 22:6n – 3. These oils are mainly obtained from capelin, herring, sandeels, herring, sprats and mackerel and in addition to PUFAs also contain large amounts of monosaturated fatty acids which are utilised as an energy source in swimming. Typically fish meal is made up of 10% lipid on a dry weight basis.

Farmed fish is a healthy food for humans, he said. The total lipid content of salmon comprises 10% of the wet weight and include the PUFAs 20 – 5n – 3, 22 – 6n –3 (5 – 6%) and 18 – 2n –6 (3 – 6%) which are important in human nutrition for maintaining the integrity of cell membranes, the manufacture of hormones in controlling physiological processes and in the prevention of cardiovascular and inflammatory disease.

No single vegetable oil is ideal as food for fish but by blending different oils with different fatty acid profiles it is possible to achieve a satisfactory formula. Substitution has shown little effect on fish growth rates although the fatty acid profile is changed to reflect that in the diet. It has been found that the more fatty acids in the diet the more they appear in the fish but the most serious affect is the levels of the important PUFAs 20:5n – 3 and 22:6n – 3, which have such a health promoting effect in humans, decreases due to their complete absence in vegetable oils. In addition oil deposition generally may increase with possible adverse affects on the flavour, texture or palatability of farmed fish. The health of the fish itself may also be compromised in subtle ways such as reduced resistance to stress and disease particularly at high replacement levels where there is already evidence of reduced immune cell number and function.

The potential advantages of vegetable oils are that dioxins and PCBs will be reduced and the level of 18:3n oils will increase. He considered replacement levels of vegetable oil for fish oil could be 100% for salmon and trout without loss of growth performance and around 60% for marine fish. Moreover these high levels could be used for most of the production cycle.

Recent and current projects at Stirling involve the applications of rape seed and palm oil and fish oil replacement in salmon and trout, sea bass and sea bream.

Environmentally friendly disinfectants

The use of hydrogen peroxide (H_20_2) as a disinfectant and treatment against disease in fish is gaining popularity with regulatory agencies, particularly in Canada and the US where its low environmental impact has been recognised. In her talk 'Healthy fish healthy business' Helma Slirrendrecht, a fish pathologist with BioMar A/S in Denmark discussed the use of chemicals in general terms concentrating in particular on the nature and use of hydrogen peroxide in fish farming.

Consumers, she began, were always asking for natural fish which did not contain drugs, pesticides or heavy metals. Healthy fish not only meant a healthy business because of better survival and growth but also a healthy environment. She defined a friendly disinfectant as safe to use by the operator, safe for the fish and the environment and be fully effective. Hydrogen peroxide based disinfectants received considerable attention last year in Denmark, she said, because of their low impact on the environment, since they break down to only water and oxygen during the disinfection process. Formalin, on the other, is toxic to the operator, decreases the oxygen content of water and although biodegradable its precipitate is also very toxic. Similarly copper sulphate can easily be overdosed leading to necrotic areas on fish gills and environmentalists are very concerned about its environmental effects.

The dosage of chemicals in general, she continued, depend on water quality and the condition of the fish. Care should always be taken when water temperatures are high and chemicals should always be used singly, not mixed. Stress and disease render fish more susceptible to treatments and it is a wise precaution to conduct a pilot scale test if a particular chemical has not been used before. Throughout the dosage period fish should be observed closely and preparations made to flush out the treatment at a moments notice. The dosage must be correctly calculated and accurate scales used to weigh out chemicals, she said. A correct diagnosis is essential, involving a vet if necessary followed by a cost benefit analysis.

For hydrogen peroxide based chemicals the dosage to kill microbes is usually lower at high water temperatures. This is because the life cycle of microbes is much faster at high temperatures allowing the disinfectant to work more efficiently. Conversely, organic material in water will inactivate a part of the hydrogen peroxide disinfectant, therefore the concentration must be increased where this is present.

Disease prevention is often better than a cure because preventive treatments slow down or stop the development of a disease outbreak. Preventative dosages of 15-20% of the full dose per week gives good results. For hatchery use 40-60g/m³ is usual. Fish are most at risk at the fry and fingerling stages from a variety of diseases and where possible bore-hole water, which is usually free of disease organisms, and concrete raceways should be used. Gill parasites often become a problem during on-growing in muddy ponds. Treatment should be started early at 100 g/m³ and at a lower concentration in concrete raceways where water quality is better. Fungal infections on brood-stock often become a problem during handling and stripping and during the period of recovery after sexual maturation. Preventive treatments at 10-20% of the usual dose per week should be used.

The talk concluded with an advertising plug on BioCare SPC a company product made up of sodium percarbonate and manufactured in granular form which breaks down during use into hydrogen peroxide and sodium carbonate. The granules are heavier than normal powder so do not blow about during use or affect the respiratory organs or eyes of the user, do not clump together during storage and can easily be applied in feed.

Some questions raised after her talk involved reports of swelling of the gills of fish during treatment but the speaker had not experienced this. Concentrations of up to 1500 g/m³ were still safe to use, the upper lethal concentration not being known and dosage times were normally about 1 hour in duration.

Algal taints

The earthy/musty taint in farmed rainbow trout continues to create problems on some UK farms and to help throw more light on the problem a LINK project was started in September, 2000. Linda Lawton of the Robert Gordon University, Aberdeen, and leader of the project, described the nature and cause of taint in farmed trout and discussed some possible solutions to the problem.

Two compounds are mainly responsible and both are produced as a metabolite of Cyanobacteria or blue green algae. These are geosmin (which literally means ‘smells like earth’) and 2-methylisoborneol (2-MIB). Cyanobacteria live mostly in river water, she said, growing in the form of a scum on surfaces and those associated with fish farms are often black in colour. Taint is seasonal, occurring between March and September when both light and water temperatures are sufficiently high to promote rapid growth of algae. Geosmin is the main compound associated with taint and this is produced and trapped within the algal cells where it accumulates for a period of about 2 weeks before being pumped out into the water. Uptake of geosmin in fish flesh occurs mainly via the gills but a small amount is taken up in water during feeding and by diffusion through the skin. Taste panel scores have revealed that geosmin is not detectable below 1 ppm while a ‘very slight’ taint score equates with 1.5 ppm and 2 ppm to a ‘slight taint’ score.

Possible methods for the elimination or minimisation of taint in fish were then considered. Both geosmin and 2-MIB are not very volatile and their removal from water by air stripping has not proved effective using realistic aeration rates, she said. The main fate of these compounds is by biodegradation but this is a slow process. For example 98% of geosmin is broken down in 72 hours while 2-MIB takes 5-14 days. Prevention of algal growth by physical removal or by reducing light access was possible but nothing could be done about high summer water temperatures and nutrient levels (mainly phosphates) both of which increase geosmin production. Depuration was a feasible solution by holding fish in clean water until the taint disappeared. The removal of taint compounds using technologies developed and applied to drinking water was another option. These included granulated activated carbon and advanced oxidation processes utilising chlorine, ozone and hydrogen peroxide although these processes would be difficult to control she admitted. A more promising solution which is still under laboratory evaluation, involves the use of ultra violet light and titanium dioxide powder. The process, known as photo catalysis, produces hydroxyl radicals which break down geosmin and 2-MIB in about 1 hour. However further work is necessary in applying this technology to a trout farm situation. At present, she concluded, the easiest management solution was to prevent tainted trout from reaching the consumer by employing a routine taste panel to sample fish on a regular basis and to stop marketing when the problem arises.

Biosecurity

Edward Branson, a veterinarian and independent consultant on fish health and production, spoke on biosecurity which he defined as the provision of an environment for farmed animals where the risk of disease is minimised. All animals, he said, have an innate ability to fight pathogens (the agents causing pathology or disease) by means of the immune system. Most micro-organisms are potentially pathogenic the main groups being bacteria, viruses, fungi and parasites.

He then described the immune system which is made up of a specific component, effective against specific pathogens, and a non-specific component (the most important system in fish) used against a range of pathogens. He visualised the immune system as being continually challenged by a range of potentially pathogenic organisms whose effects were suppressed when they occurred below a certain threshold level. When the challenge exceeded the threshold a disease outbreak may occur. To maximise the threshold level of resistance he said fish should be fed with good quality food, given immuno stimulants and vaccines and maintained at a high level of husbandry. Alternatively there were a number of conditions which reduced the threshold level of resistance leaving fish more vulnerable to disease outbreaks. The most important here was stress which he defined as the effect of any environmental alteration or force that extends homeostatic or stabilising processes beyond normal limits. This could amount to a single acute stress such as a sudden drop in oxygen concentration, an accumulation of several acute stress events as in grading and vaccination or a prolonged chronic stress as in crowding.

A wide variety of external factors caused stress which could be divided into:

- husbandry/management practices such as handling, poor feeding practices, high stocking densities, predators, photoperiod (no direct evidence here) and general staff awareness.

- environmental factors such as poor water quality (suspended solids, ammonia, super saturation, ozone, enzymes and metals), low oxygen, high carbon dioxide, nitrates, temperature and rapid water quality changes.

Reducing stress levels to a minimum not only helps maximise resistance to disease but promote good growth rate, reduced FCR and increased carcass quality. Similarly any procedures that reduce the exposure of fish to potential pathogens entering the farm is clearly beneficial in preventing disease. Examples here are containment of broodstock and eggs to one part of the farm, disinfection of equipment and vehicles and the use of one way flow systems. Ideally, he said, the farm should be self sufficient and not bring in new fish. ISA in Scotland, for example, is believed to have stemmed from a single site that got transferred to other farms by contaminated personnel or equipment. The impact of a pathogen entering the farm can often be reduced by careful observation of fish, instigating monitoring and routine sampling, quick removal of dead and dying fish, and by isolation and disinfection. Fallowing was also very effective, where possible, although this was not easy on trout farms.

He summarised by saying the four key areas for ensuring fish remain healthy were (a) maintain the fish's immune system in top condition by supplying a good diet (b) provide a good environment to reduce stress (c) reduce pathogen levels and avoid entry of new diseases (d) apply good husbandry procedures.

The broiler industry

Mike Alcorn, a Group Director of O'Kane Poultry Ltd, with special responsibilities for technical, veterinary and food safety issues described the evolution of the broiler industry, indicating where lessons could be learnt for the trout industry.

Starting in the 1950s as a small cottage industry with low volume and many competing undeveloped breeds it is now a massive industry integrated into only 2 large company's which together supply 50% of the meat consumed in Britain. Today the industry is characterised by a market driven production where the requirement is for high volume, diverse and sophisticated products. Only a small number of highly developed breeds are involved and throughout the computer controlled production cycle disease prevention is paramount. Infection is not allowed to get in and on-site laboratory testing takes place constantly. Nutritional techniques used are relatively sophisticated and all food is heat-treated. Hatchery production amounts to half a million chicks per week and growth is rapid taking only 33 days to harvest.

The most significant changes that have affected the poultry industry lie in the areas of genetics, processing technology, nutrition and health. These had made the greatest impact involving many characteristics such as FCR, meat yield and growth rate. Quoting examples of improvements since the 1950s he said the FCR had increased from 1:4 to 1:1.8, white breast meat yield from 10 to 20% and days to market from 70 to 32/33.

Processing, he said was automatic involving imaging systems and currently the only manual process was the initial 'hang on' of the birds to the processing line. These can handle 12-15,000 birds per hour and full traceability of the product through the system is possible. In 1960 only 5% of birds were further processed compared to 90% in 1998. This provided a wider customer profile and produced differentiation and distinction to products. A wide variety of added value products are now available using sophisticated packaging techniques such as cook in bag, lip seal packs, controlled atmosphere and active packaging. Although these could be profitable capital costs were high and products had a high failure rate (95%), often short lived due to the rapid arrival of 'copy cat' products and product imbalances. Wastage was also an ever-present problem, for example for every 100 chicken breasts only 7 legs could be sold. The trick was to sell the whole product.

Continuing with nutrition he said an increased understanding of nutritional requirements, aided by computerised formulation and advances in processing technology had greatly improved feed quality over the years. The use of synthetic amino acids and new enzyme technology had allowed the utilisation of new materials to be made such as barley which is replacing some raw materials that are no longer acceptable such as animal proteins and same species recycling. Turning to health he said the availability of vaccines and improved medicines, together with management strategies (all in all out) and hygiene procedures (farm disinfection) had all played a part in improving the health of flocks. Improved diagnostic techniques had helped eliminate vertically transmitted diseases as well as selection for genetic resistance to diseases. In spite of this mortality rates had stayed at 4% since the 1950s owing to increases in metabolic disorders caused by the increased growth rates and stress this creates. Health issues continue to pose a threat due to intensification, appearance of new diseases, reappearance of old ones and the problems of resistant infections and more virulent diseases.

He concluded with some advice that he thought was very relevant to the trout industry. Both industries should avoid consumer scares, zoonoses (salmonella/ campylobacter), residues, animal welfare issues and environmental stress. On the other hand, useful things to promote was the establishment of a brand, be sales not production driven, look at what other industries are doing and copy them if they appear to be a good idea and finally to enjoy your business.

BTA chairman's address

The final talk of the afternoon's session was given by Robin Scott of Nidderdale Trout Farm who succeeded Mark Davies as BTA chairman in February, 2001. He began his address by recalling the Promar report which had been highly critical of the industry, describing it as suspicious, inward looking with an attitude of blame. He thought attitudes were improving now in which the processors were paying more attention to key customers and recognising that added value was the only way forward. The report had predicted 25% of farms were at risk of going under and he considered this had probably come about, leaving only the strong to survive. Promar's recommendations of consolidation, increased production and genuine improvements in product composition was now thought to be happening but more was needed. Production levels must go up, he said, but with more emphasis on boneless fillets.

Interpreting the phrase 'get real or get out' used in the report, he said the BTA was not able to influence the food market which could only be market driven. Support for the industry relied on facilitating Research and Development in establishing best practice and improving biological performance.

In order to represent all facets of the trout industry, he said the BTA was re-structuring its representation on the council. This was desirable to ensure that representation was not dominated by the larger producers and to bring in younger members of the industry with new ideas. The latter was proving difficult, he confessed, as younger people were very busy running their own farms and not committed to doing work on the BTA so old faces would persist.

Moving on to research, he said their had been a number of successes in recent years in finding solutions to problems, particularly on the disease front. The new project on improving strains of trout was an important development with great potential. It was important, he said, that membership provide feedback in what is being done on research projects.

On-going problem areas were then reviewed starting with extraction and discharge licensing and charging. The paper given by Christopher Saunders-Davies at the previous conference, outlining an alternative approach to discharge regulation involving self monitoring, was being taken forward with the Environment Agency and a satisfactory resolution was looking promising. Fish movement legislation followed in which EU proposals for re-classification of notifiable diseases and the possible removal of List 3 was discussed. The intention was to free up trade in Europe by relaxation of movement controls. There were some countries pressing for the removal of VHS from the list which was clearly not in the interests of the UK and quite how it would be resolved remains to be seen.

Organic production was mentioned, where great progress had been made in the development of standards and feeds. He thought there was now an established demand for organic trout but the supply was patchy at a time when retailers were requiring a more plentiful and cheaper product. He considered the returns to growers in this area may be disappointing.

The MAFF initiative set up by Elliot Morley to develop a credible, affordable assurance scheme resulted in Scottish Quality Trout rolling out its standard to the rest of the industry. 'We should be grateful' he said as a high quality product is essential if the industry was to succeed. The consolidation of Andwell Mill, Alderley Trout and Trafalgar Fisheries to form Sarum Foods Ltd was another result of this iniative. Specialising in added value processing, the consortium was created out of the requirement for retailers wanting to deal with a single distributer.

The Foot and Mouth epidemic had severely affected some farms, particularly those involved in brown trout restocking and where applications had been made for compensation some had been paid up. The restocking industry had shown some recovery late in the season, but generally this sector appeared to be declining year on year.

He finished with some thoughts on future trends. There was room for increasing prices as these were going up in supermarkets at present and for increasing quality and supply including organic production. Added value increased profitability and this would form the main challenge for the trout industry over the next few years.

PHOTOPERIOD MANIPULATION CAN BE USED TO IMPROVE GROWTH RATE AND FEEDING EFFICIENCY IN RAINBOW TROUT

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Introduction

Traditionally, photoperiod manipulation has been confined to altering the spawning times of broodstock maintained in covered tanks. Using these techniques trout farmers can now successfully advance or delay spawning times and hence egg/fry availability. However, recent work on other species using high intensity lighting in uncovered systems, i.e cages, tanks and ponds, has highlighted a further and possibly more important advantage through increased growth and feed conversion efficiency. This work outlines the present studies in transferring this technology from the salmon and Mediterranean industries to UK trout farms.

Reproduction

In most temperate spawning species, including salmonids, it is now widely accepted that the pattern of seasonally changing daylength is primarily responsible for synchronising the timing of reproduction (Bromage *et al*., 1994). Although modified light regimes can be used successfully to compress (advance) or extend (delay) the spawning period, it is now evident that the increasing and decreasing components of the seasonally changing daylength can be replaced by square wave photoperiod profiles. An important consideration when using photoperiod manipulation is that varying the position of the continuous light period in relation to the phase of the reproductive cycle may affect both the time of spawning, but also the proportion of fish that spawn out of season. Duston and Bromage (1988) proposed that these variations could be explained by a ‘gating mechanism’, whereby fish will only mature (undergo puberty) in a particular year if they had reached a certain threshold stage of reproductive development or size while the circannual clock is at a specific (gate-open) phase of the circannual cycle. In contrast, those failing to reach this threshold before the gate closes remain immature until the following year. In all vertebrates, puberty occurs when individuals have reached a certain age and size and accumulated enough energy stores to ensure the success of reproduction. Therefore, hormones implicated in the control of growth (growth factors, growth hormone) and energetic metabolism (leptin) are likely to play a key role in the onset and time course of puberty (Bromage *et al*., 2001).

Trials to determine potential growth and metabolic signals responsible for the initiation of puberty in rainbow trout help explain the problems associated with reduction in the number of fish responding to advanced photoperiod regimes.

In January one hundred and twenty 460±5 g two year-old virgin female rainbow trout were individually P.I.T. tagged, then split randomly between two 5 m-diameter indoor tanks and held on an ambient photoperiod. Tanks were maintained under blackout covers with two fluorescent tubes positioned 1m above the water surface providing artificial illumination in each tank (Figure 1). From the 31 January one group of fish (Control) remained on a simulated natural photoperiod (SNP) and a second group (ADV) was subjected to constant long-days (18L:6D) until May after which they were given a constant short-day (6L:18D).

Figure 1. Typical blackout covers used on indoor tanks

Under SNP, 62.75% of the total population underwent maturation and spawned successfully. It is evident that those that matured grew at a significantly greater rate than those that did not initiate maturation as indicated by increased mean body weights from May to October (Figure 2a). As expected fewer fish responded to the advanced photoperiod regime with only 29.4% of the total population successfully spawning. The split in the population between maturing and non-maturing fish was evident from September onwards (Figure 2b). However, prior to this period, growth rate and body size appeared relatively similar which poses the question as to why some individuals initiated maturation while others did not. Currently work is being undertaken to analyse hormone levels to assess which factors may be responsible for this observed decision to initiate maturation despite apparently similar body size and growth rate.

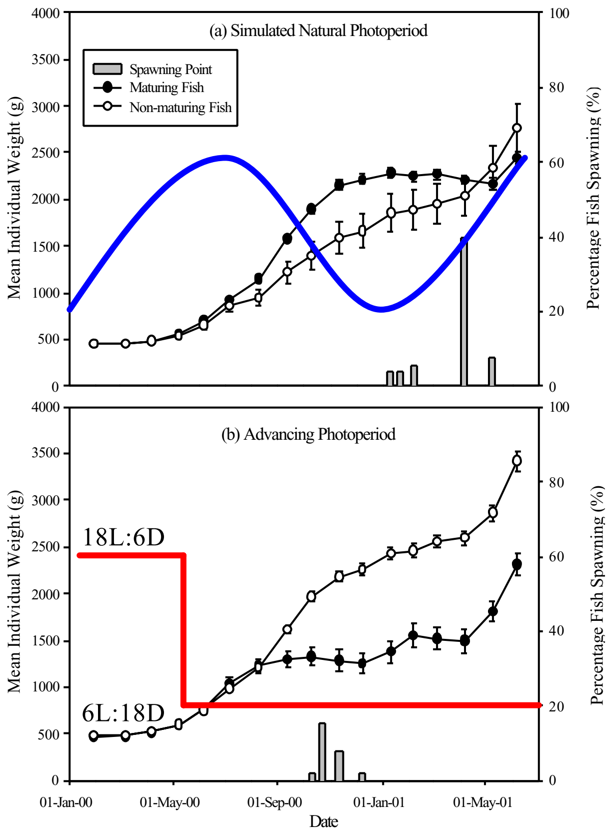

Figure 2. Growth rate and spawning period of broodstock rainbow trout maintained under natural and advancing photoperiod regimes. (a) Natural spawning period (Mar-Apr). (b) 6 month advance in spawning period (Oct-Nov)

Photoperiod as a Growth Enhancement Tool

Although fish are ectotherms with many of their somatic and reproductive functions being dependent on temperature, there are other external factors involved in these processes, not least the influence of light. Constant light and long-day photoperiods have been shown to increase growth in the juvenile and ongrowing stages of Atlantic salmon and are now general practice on salmon farms (Porter *et al*., 1999; Taranger *et al*., 1999; Oppedal *et al*., 1997). However, the use of such artificial lighting regimes are not yet being fully utilised by the trout industry and research into the effect of photoperiod on growth in trout species has received little attention. In the case of the rainbow trout, evidence suggests that rapid growth is not associated with maturation and that exposure to long-day photoperiods can improve growth rate (Skarphedinsson *et al*., 1985), who demonstrated that exposure to LD 14:10 produced the best growth. Makinen & Ruhonen, (1992) showed that under natural photoperiod cycles a reduction in the rate of decreased daylength was favourable for growth and feed conversion efficiency. Mason *et al*., (1992) proposed that rainbow trout maintained under LD 16:8 and fed throughout the sixteen hour period performed better than those maintained on 16 hour light but fed only throughout the daylight hours, due to the longer photophase providing more favourable conditions for an increase in food intake. However, it has been shown that artificial light improves growth through better feeding efficiency and not just through increased food intake (Boeuf & Le Bail, 1999).

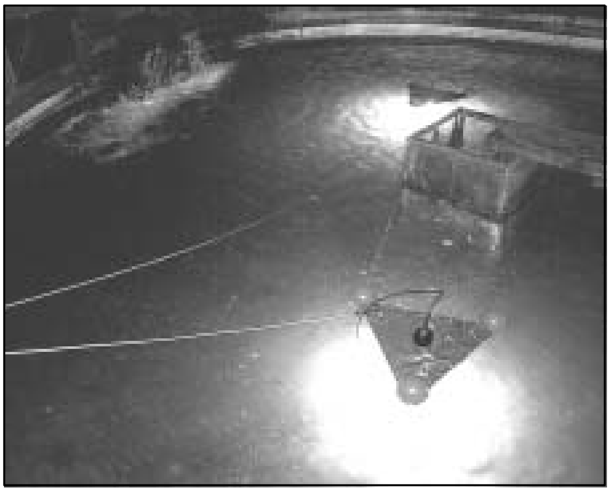

Figure 3. Floating light units used to provide artificial illumination in outdoor ponds

An experiment aimed at assessing the effects of additional illumination on FCR was conducted from November 2000 to May 2001.

Four 4 m diameter tanks were stocked with equal numbers (50,000) of rainbow trout fry giving a total biomass of 250 kg per tank. Four treatments were used:

- ambient photoperiod fed during daylight hours (AA)
- constant light and ambient feeding (LA)
- constant light with 24 hour feeding (LE)
- constant light in a covered tank with extended feeding (IL).

Lighting in each outdoor tank was provided by two Aquabeam 400 w Pisces floating light units (Figure 3). Lighting in the covered tank was provided by fluorescent tubes positioned 3 metres above the tank. Feeding was extended into the night using clockwork belt feeders.

Following one-month exposure to constant light (LL) groups on ambient feeding were significantly larger ($p<0.05$). By the end of the trial all groups on LL were significantly heavier than the controls (Figure 4). Feed conversion (FCR) was improved under all LL treatments relative to the controls, with significantly greater improvements observed under LL and ambient feeding alone (LA) (Table 1). Significant improvements in specific growth rate (SGR) over the controls were also observed in all LL treatments (Table 1) as reflected in the greater weight gains (Figure 4).

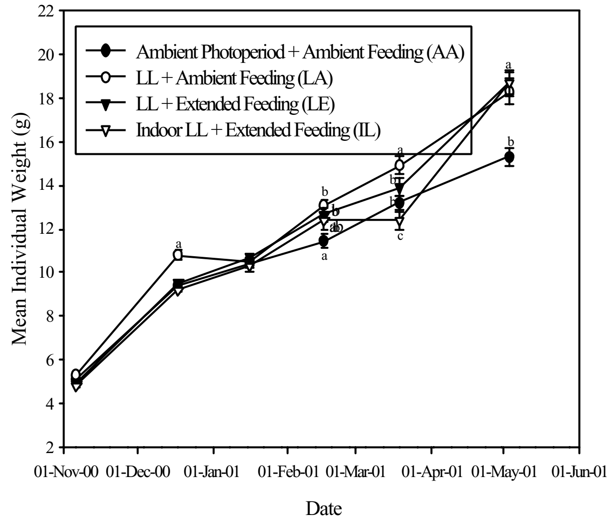

Figure 4. Influence of constant artificial light and feeding regime on individual mean weight±SEM in rainbow trout fry held in tanks (n=200). Points having different superscripts are significantly different, p<0.05 (One-Way ANOVA)

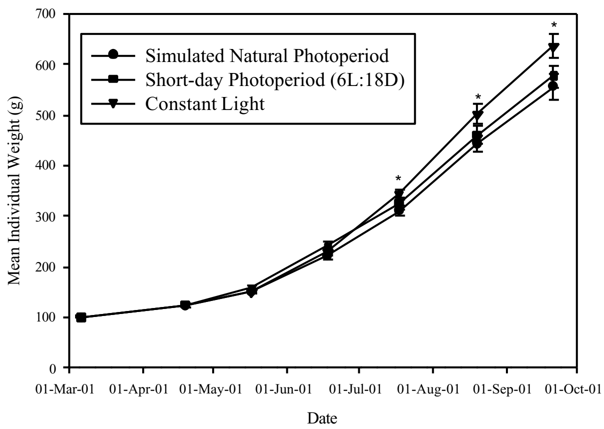

Figure 5. The influence of photoperiod regime on the growth of rainbow trout juveniles maintained in covered tanks (SNP: simulated natural photoperiod; SD: short day, 6L:18D; and LL: constant light). * Significantly different (p<0.05 One-Way ANOVA)

The data shows that the provision of an extended photoperiod during the winter period can improve growth rate (SGR) in the rainbow trout, with those maintained on constant light reaching a greater weight than those under ambient conditions. No added benefit was found if the fish on artificial light were maintained on an extended feeding regime (LE). This suggests that improved growth was achieved by the perception of increased daylength alone. More importantly from a fish farmers perspective, the current study clearly demonstrated that feeding efficiency (FCR) was greatly improved under constant light (LA group). This would represent a significant reduction in farm expenditure through the better utilisation of feed.

Table 1. Comparison of percentage weight gain per day (Total SGR) and feed conversion (Total FCR) of treatments relative to ambient (Control) group

Treatment	SGR % Improvement over control	FCR % Improvement over control
LA	+20%	+74.6%
LE	+15%	+25.2%
IL	+21.7%	+29.9%

Similar results have been achieved during juvenile ongrowing stages of production. The exposure of fish (101 g ±2) in covered tanks (2 m diameter) to constant light (LL) from April onwards resulted in a significantly larger mean weight, +14.3% and +10.1%, entering the autumn period (September) compared to those maintained under natural or short-day photoperiod regimes respectively (Figure 5). These fish were fed only through the period of the short-day group. Such an increase in size entering the winter period could provide considerable advantages to the trout farmer, especially if the growth advantage could be maintained throughout the winter growing season.

Other Trials

The group at Stirling is currently working on whether submersible cage lighting can be used to successfully enhance winter trout growth in freshwater cages. The use of floating lights in raceways is also being investigated to determine the number of units and intensity of light that may be required to enhance growth rate during the latter stages of trout production. These studies could provide valuable information for improving production in outdoor systems whereby superimposing artificial light on ambient levels is more difficult than in covered units such as tanks.

Acknowledgements

This work was initiated by Clive Randall with support from the Natural Environment Research Council ROPA Grant. Geoff Farrow (Aquabeam Ltd.), Nick Younge, Graham Milroy, Mark Grant (Galahaugh Fish Farm), Mark Davies, Guy Warburton, Ian McMillan (Glenkens Fish Farm), Stuart Hall, John Gardener, Alistair McPhee (Buckieburn Freshwater Research Facility).

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PYCEZE® –A SAFE AND EFFECTIVE TREATMENT FOR *SAPROLEGNIA* INFECTION

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On July 12th 2001, Pyceze was granted a UK Provisional Marketing Authorisation (PMA) for the treatment and prevention of *Saprolegnia* infection in farmed, fertilized salmonid eggs. This is the culmination of many years spent in research and development, to provide trout and salmon farmers with a fully authorised medicine for this most important problem. Pyceze is already approved for use in Norway, Sweden, Finland and Faroes Islands, and is being trialled in Chile, Denmark, North America and Ireland. Work on fish is well advanced and we expect to submit a dossier to the Veterinary Medicines Directorate within 6 months

What is Pyceze?

Pyceze is a clear liquid containing 50% w/v bronopol BP (2 – bromo – nitropropane – 1,3 diol) as the active ingredient. Bronopol itself is a broad spectrum anti-microbial agent, widely used in over 40 countries, principally as a preservative in health care and cosmetic products. It has an excellent human safety profile.

Regulatory status

Pyceze has a Provisional Marketing Authorisation. This regulatory mechanism exists to expedite the availability of medicines in cases where no authorised product exists, and for conditions with major economic and welfare implications. For the user there are no implications of the provisional status. For Novartis Animal Vaccines Ltd (NAVL) it means compliance with certain specific conditions attached to the authorisation.

Pyceze is a Prescription Only Medicine (POM) available through veterinary surgeons. This is normal practice for novel products and those authorised under the PMA procedure.

Dose for salmonid eggs

The target dose is 1 ml Pyceze per 10 litres incubator water (equivalent to 50 mg bronopol per litre) for 30 minutes. The exact method of application will depend on local conditions and hatchery design, and detailed written guidance will be provided.

To satisfy the regulators, NAVL has provided comprehensive data on safety, quality and efficacy

Target species safety

Several tolerance studies have been carried out on salmon and trout eggs, four to GLP standard. As an example, one trial on Atlantic salmon eggs is detailed below.

Six groups of 400 fertilised eggs were set up at a hatchery in Scotland and treated daily for 81 consecutive days as follows:

Group 1 negative control

Group 2 Bronopol 50 mg l^{-1} (target dose) for 30 minutes (target duration)

Group 3 Bronopol 50 mg l^{-1} (target dose) for 1 hour (2x target duration)

Group 4 Bronopol 150 mg l^{-1} (3x target dose) for 1 hour (2x target duration)

Group 5 Bronopol 250 mg l^{-1} (5x target dose) for 1 hour (2x target duration)

Group 6 Malachite green 1 ppm for 1 hour (traditional dose)

Each group was replicated and observed up to first feeding. The temperature during the trial varied from 4-9°C.

There was no significant difference in survival between any of the Pyceze treated groups and control, and significantly worse survival in the Malachite green treated group.

Observations were also made on alevin length and visible deformities. There were significantly more deformed alevins in Group 6 (malachite green) compared to all other groups, both as a percentage of survivors ($p<0.01$) and as a percentage of eggs incubated ($p<0.001$). There was no significant difference between any bronopol treated group and control.

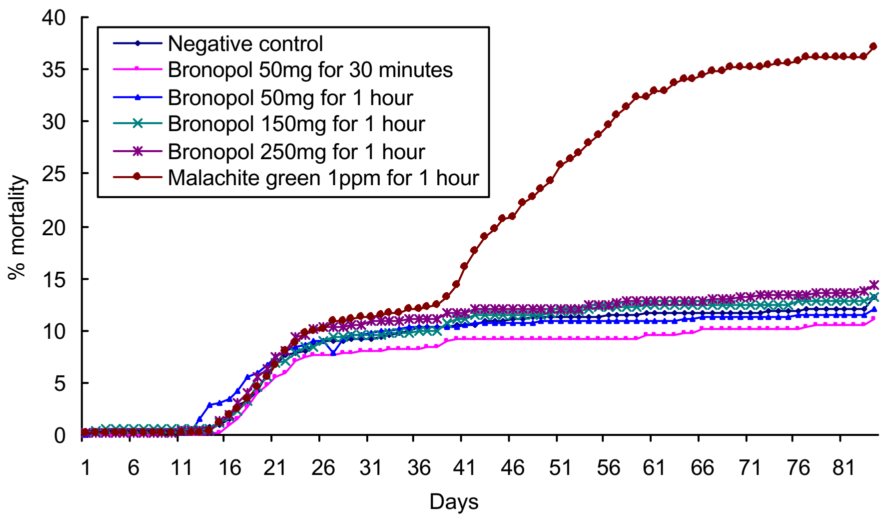
These results are typical of those conducted here and in other countries, and clearly demonstrate the wide margin of safety for eggs.

Safety to the environment

The use of Pyceze in hatcheries may result in the discharge of bronopol to controlled waters and it was therefore a requirement of authorisation that potential for environmental impact be examined.

Fortunately a large amount of data already exists for bronopol but additional data specific to this application had to be generated. A comprehensive environmental risk assessment was carried out to enable regulators to gauge environmental impact following the use of Pyceze by fish farmers.

Bronopol has a relatively short (hours) half-life in freshwater, is biodegraded, does not readily absorb to soils/sediments and does not have a tendency to bio-accumulate. It has been tested for toxicity against a wide



Cumulative (mean) egg mortality

range of vertebrate and invertebrate species and, in the assessment, was found to present no significant risk to non-target species when used as recommended.

Operator safety

Undiluted, Pyceze can be irritating to eyes and skin and users are advised to wear protective clothing when there is a risk of exposure to the product. It is non-irritant when diluted to its working concentration.

Consumer safety

A variety of legislation exists to protect consumers but in respect of medicines used in animals for human consumption, there is a specific requirement to demonstrate that there will be no harmful residues present in treated animals at the point of slaughter and this is usually achieved by applying a withdrawal period. This is of little relevance to use on eggs (though fertilised eggs are regarded as animals), but will be important for use in fish.

Amendment 434/97 of Directive 2377/90 prohibits the administration to a food producing animal of any active not in Annex I, II or III.

Bronopol has been assessed by the Committee for Veterinary Medicinal Products (CVMP) and has been placed in Annex II for eggs (no MRL required). This will apply also to fish, therefore, following the use of Pyceze in fish, no withdrawal period will be required.

It should be noted that malachite green is not in Annex I, II or III, and, therefore, under this legislation, it is illegal to administer it to a food producing animal (including fertilised eggs).

Quality

Pyceze is a clear, colourless to pale yellow solution containing bronopol 50% w/v in an inert carrier to 100% w/v. The formulation is stable for 3 years and one which can easily be mixed with hatchery waters at a range of concentrations. Pyceze is manufactured by Novartis in a GMP compliant facility and supporting analytical methods have been developed for the analysis of both the raw material and the finished product. The product is presented in a pack containing 5 x 1 litre bottles, complete with measuring cylinders and detailed guidance.

Efficacy

A GCP(v) compliant field efficacy study was conducted in Atlantic salmon and rainbow trout eggs

- 11 site study in UK, Ireland, Denmark and The Faroe Islands
- 1500-200,000 eggs per replicate
- 2 groups: Pyceze 700,500 eggs, Placebo 450,500 eggs
- Daily treatment with Pyceze (50 mg l^{-1} bronopol) or placebo according to normal hatchery routine.
- Dead/infertile and infected eggs were not removed during treatment

Fungal scoring system

Infection Status		Fungal Score
Absent	No obvious fungal infection	0
Very Mild	Very small fungal clumps 1 to 5 eggs	1
Mild	Small fungal clumps >5 to 10 eggs	2
Mild/Moderate	Established infection >10 eggs but <10% coverage	3
Moderate	10 to 50% coverage of fungus	4
Moderate/Severe	50 to 75% coverage of fungus	5
Severe	75 to 100% coverage of fungus	6
Total	100% coverage of fungus	7

Scoring was carried out 'blind'. *Saprolegnia parasitica* was identified in each case

Results

PYCEZE PLACEBO

Typical results of treatment with Pyceze. Note that even in the presence of dead eggs in the trial incubator, fungus is absent

Mean Fungal Scores

Treatment	Total number of incubators	Mean fungal score
Pyceze	31	1.7
Placebo	26	5.0

Pyceze significantly reduced the mean fungal score ($p<0.001$)

Mean percentage infection per incubator

Treatment	Total number of incubators	Mean % fungal infection	Comparative % protection
Pyceze	31	5.2	91
Placebo	26	56.3	

Pyceze significantly reduced the mean infection per incubator ($p<0.001$)

Total percentage infection (pooled results)

Treatment	Total number of incubators	Mean % fungal infection	Comparative % protection
Pyceze	31	3.8	95
Placebo	26	80.0	

Pyceze significantly reduced the percentage of eggs with fungal infection ($p<0.001$)

Pyceze significantly reduced the severity of fungal infection ($p=0.00003$)

The Future

The next milestone for Pyceze will be the MA for fish in the UK and in the rest of Europe. Beyond that we are investigating the potential for extending the indications and species range to take advantage of the potent anti-bacterial properties of bronopol. Particular areas of interest are warm water marine species, ornamentals and invertebrates.

TOWARDS AN AUTOMATED SYSTEM FOR THE IDENTIFICATION OF NOTIFIABLE PATHOGENS

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The movement of fish across country borders by man has resulted in the introduction of exotic parasite species to indigenous fish stocks. The translocation and spread of these parasites has increased over the last 20 years despite legal proscriptions on the movement of infected fish. In recent years, we have seen the introduction of, amongst others, the pathogenic tapeworm *Khawia sinensis* (Yeomans, Chubb & Sweeting, 1997) as well as a number of serious waterborne diseases such as crayfish plague (Alderman, 1996). Some of the introduced parasites are known to be serious pathogens and their effect may be critical for conservation, fisheries management and aquaculture. To prevent the import and spread of potential pathogens into the UK, the European Fish Health Directive 91/67/EEC restricts the importation of live fish into the UK, while the Diseases of Fish Acts of 1937 and 1983 allow certain diseases to be made notifiable and permits movement controls on fish where a notifiable disease is suspected or confirmed. The early detection of a notifiable disease is crucial for its containment and is dependent upon the rigour of the analytical tools and methodology in use to provide a confident diagnosis. If a notifiable bacterial or viral borne disease is suspected, confirmation of the disease can take anything from 7 to 49 days. The speciation of higher organisms, such as parasitic worms etc., is dependent upon taxonomists to provide an identification. This can take time and depends on the quality of the specimens and having access to archived material for comparison. *Gyrodactylus salaris* is a highly pathogenic skin fluke, which has had a devastating effect on salmon in Norway but does not occur in the UK (Shinn *et al.,* 1995). Nevertheless it has been reported from ten neighbouring European countries. Since the introduction of *G. salaris* into Norway from Sweden in the 1970s, it has spread to 41 rivers and 37 fish farms. Salmon parr mortalities in rivers can be as high as 95% and the situation has necessitated the use of rotenone in certain rivers to remove all fish species and thus the parasite, before restocking at a later date. Although *G. salaris* is a parasite of salmonids, it may be transmitted by numerous other temporary hosts including eels and flounders. *G. salaris* (Figure 1), was made a List III pathogen and thus notifiable in the UK in 1988. However, there is no standardised method of identification at the present. Its discrimination from other, relatively benign gyrodactylids parasitising salmonids, is dependent upon highly trained experts in specialist laboratories, separating species on the subtle differences

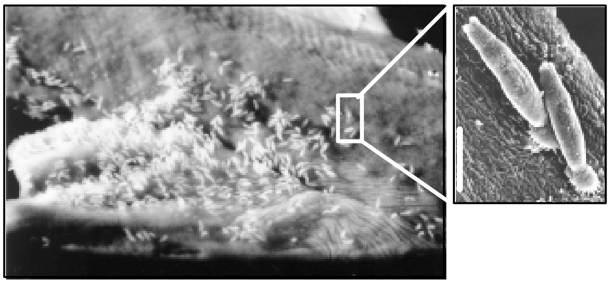

Figure 1. A heavy infection of Gyrodactylus salaris on a 1 cm long pectoral fin of an Atlantic salmon parr from Norway. The inset shows two gyrodactylids. Scale bar = 0.2 mm

in the shape of the attachment hooks (Figure 2). Molecular based methods are being developed but are not yet sufficiently reliable and require specialised laboratories, facilities and equipment. Thus there is an urgent requirement for the rapid and certain identification of *G. salaris* to control this disease.

Imagine a system of identification that negates the need for a specialist to identify the parasites. A system that has low running costs, is simple to use, requires very little input by the operator and yet is able to unequivocally detect this pathogen in any given population. We have been developing just such a technique. With the combined use of image analysis and statistical classifiers we are able to distinguish *G. salaris* from other species of *Gyrodactylus* parasitising salmonids. We now have a reliable methodology able to discriminate *G. salaris* from closely-related species which occur on Atlantic salmon, brown trout, rainbow trout, charr and grayling. This technique involves the training of an artificial intelligence system (AIS). For several years we have been studying systematic diagnostic methodologies and have developed semi-

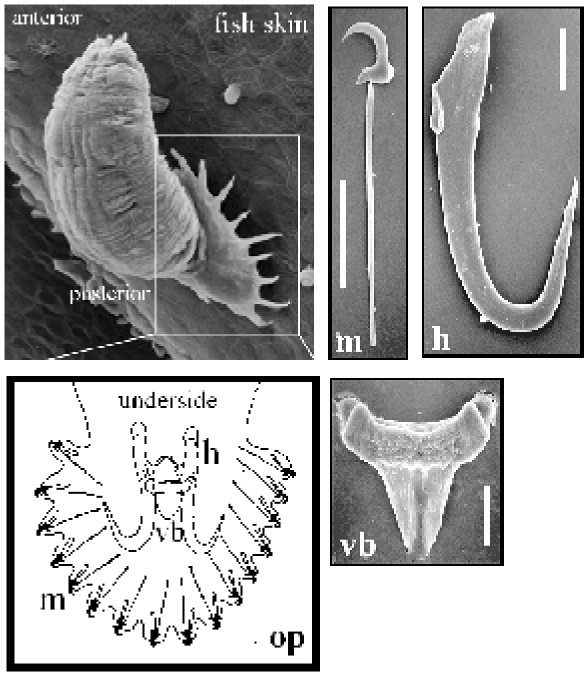

Figure 2. Gyrodactylus attached by its opisthaptor (op) to the epidermis of its fish host. The opisthaptor or attachment organ houses 14 peripherally distributed marginal hooks (m) and a central complex of two large anchors or hamuli (h) which are connected by two bars, the dorsal bar (not shown) and the ventral bar (vb). The hooks of each species have a unique size and shape. Scale bar = 10 microns

automated classification systems for identifying *G salaris* (Kay *et al*., 1999; McHugh *et al*., 2000; Shinn *et al.,* 2000). These studies have involved the collection of large data sets of measurements which we have used to train the classifier (the AIS). We are now in the process

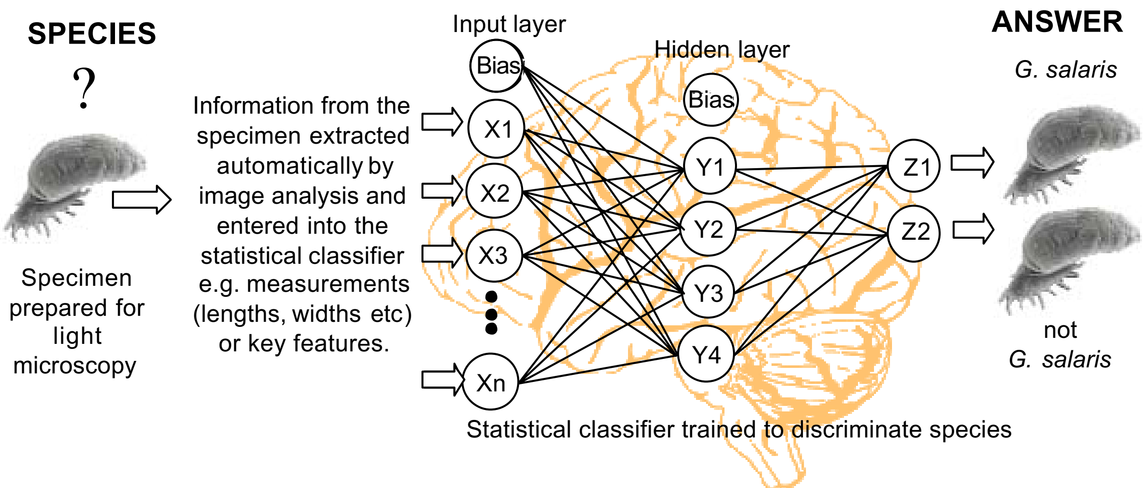

Figure 3. The identification process using an Artificial Intelligence System. Specimens are prepared for light microscopy, image analysis is then used to extract the key features and these are fed automatically into a computer programmed with the statistical classifier, which will then give an answer as to whether the specimen is G. salaris or some other Gyrodactylus species

of developing specimen preparation methods and a computer programme which can be used by non-specialist operators. For identification, the parasite is mounted on a glass slide and viewed using a light microscope linked to a computer. Image software is used to collect data on the hooks which is then fed automatically into a statistical classifier to identify the species under analysis (Figure 3). The statistical classifier has already been trained by an expert to identify species of *Gyrodactylus*. This was done by exposing it to a huge database of images and measurements and, by adjusting the system until it always gives the correct answer when presented with each species, it will confidently decide if the specimen is *G. salaris* or not. Figure 4 shows the morphological similarity of the marginal hooks of four *Gyrodactylus* species, including *G. salaris*, that the diagnostic system is able to correctly identify. This system has already shown itself to be more reliable than current PCR methods and can even distinguish *G. salaris* from its closest relative *G. thymalli*. The system will assist fish health inspectors in the diagnosis of this serious disease of salmonids who can then prevent its spread, thereby protecting the United Kingdom's valuable wild and farmed salmonid stocks.

A two year project is funded by DEFRA to provide a semi-automated system of identifying *G. salaris* which will be then tested out by colleagues Steve Feist and Matt Longshaw at CEFAS, Weymouth who are also assisting in the collection of specimens to refine the training of the system and to ensure classification efficiency and ease of use.

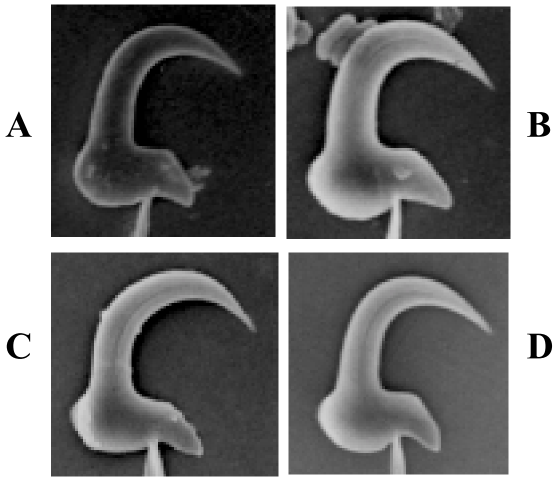

Figure 4. The novel diagnostic system is able to discriminate and correctly identify the marginal hooks of, for example, the following four species of Gyrodactylus parasitising salmonids.
A = G. caledoniensis; B = G. derjavini;
C = G. salaris; D = G. truttae

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AQUACULTURE MEDICINES PART 1

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As some of you will be aware an extended programme of research into the difficulties and problems associated with the use of medicines in the aquatic environment has been ongoing for a good many years at CEFAS Weymouth funded by MAFF/DEFRA Fisheries Division.. From time to time brief notes have been published in Trout News explaining some of the more practical aspects of the outcomes of that research. Apart from maintaining a watching brief, that programme of research is now largely completed and it was felt that it might be useful to give a brief overview of some of the major achievements. Part 2 of this overview will appear in the next edition of Trout News.

The series of projects started nearly 15 years ago when our understanding of the ways in which medicines, particularly antibiotics behaved in fish was fairly limited. One of the first actions was to produce an extensive overview of the state of knowledge of aquaculture medicines (Alderman, 1988) to establish the major needs for new research. At the beginning of the 1980s the period required between end of medication and earliest time of slaughter (the with-holding period) was set in terms of a fixed number of days. Our own research confirmed that the effect of water temperature on fish metabolism was very great and played a major role in the speed with which drugs depleted from fish tissues. In Norway, fixed numbers of days with-holding were established with cut off temperature points below which the day count would cease until water temperatures increased. From our own research we proposed using the well established degree day approach in which with-holding periods were set as cumulative degree days. This takes full account of the effect of changing water temperatures, but avoids low temperature cut off points that could lock up fish for months in winter. This approach together with the view that data from studies carried out at two different water temperatures should be used to define the degree day with-holding period was adopted in the U.K. This approach is now effectively the standard approach used throughout Europe.

It was also clear that there were increasing worries about the potential adverse effects of extensive use of antibiotics in aquaculture. These risks were mainly seen to relate to increased antibiotic resistance. For the fish farmer, this meant that diseases such as furunculosis became increasingly difficult to treat as *Aeromonas salmonicida* became less sensitive to the antibiotics that were authorised for use on fish. More seriously it was also seen as an environmental impact hazard and a risk to consumer health because of the perceived risk that antibiotic resistance might transfer to human pathogenic bacteria.

Setting up a quantitative study into changes in antibiotic resistance patterns in the aquatic environment proved very difficult, but over a number of years we were unable to find any correlation in shifts in antibiotic resistance in river bacteria and use on adjacent fish farms.

In the laboratory we set up a study selecting for antibiotic resistance using an MSc student from the University of Stirling. Deliberate selection for resistance proved relatively easy with *A. salmonicida* becoming resistant to a 3 log increase in dose levels over a very few generations. Once established the higher levels of drug resistance were found to be very persistent in the laboratory. The study also looked at a range of isolates of *A. salmonicida* from Weymouth and Stirling that had been collected over the previous twenty years. A clear shift in antibiotic sensitivities against time and reflecting changes in drug availability was evident, thus isolates collected before the introduction of oxolinic acid showed a greater sensitivity to 4 quinolone antimicrobials than those collected after. The methods and approaches used in this study have become a standard reference in fish bacteriology (Tsoumas *et al* 1989).

A similar study to that on *A. salmonicida* was also carried out on the ERM agent, *Yersinia ruckeri*. Again, deliberate selection of resistance under laboratory conditions was shown to be easy. The results of both studies confirmed field observations that repeated use of the same antimicrobial agents could result in those agents loosing efficacy very rapidly. At the time there was a strong tendency to want to use the same antimicrobial agent repeatedly at the same site with the reasoning that the drug was of known efficacy. The fact that antimicrobial resistance once established in a bacterial population did not fall away again rapidly once use of that drug stopped particularly with the 4-quinolone antimicrobials was not well appreciated.

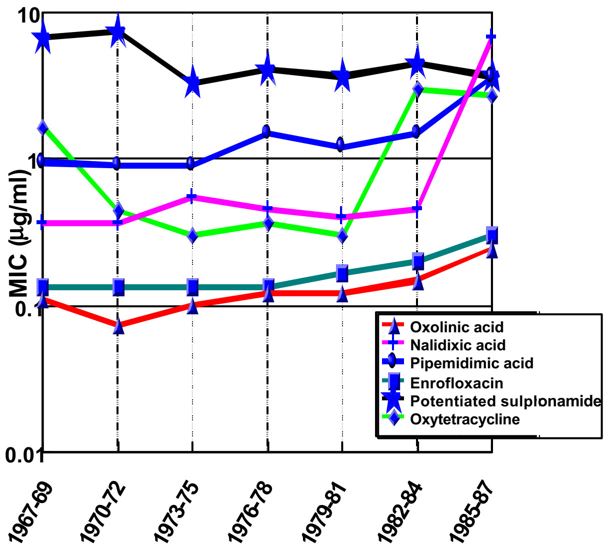

Figure 1. Changes in antibiotic sensitivity in A. salmonicida over 20 years

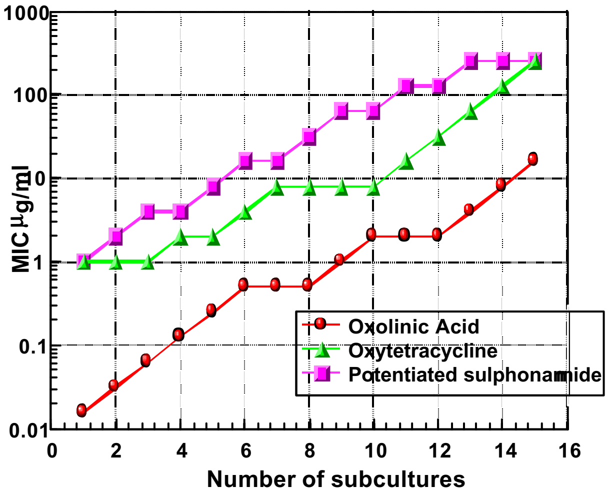

Figure 2. Laboratory selection for antibiotic resistance

A major chance to review progress with research into the use of medicines in aquaculture came with a major international conference chemotherapy in aquaculture in 1991 at the Office Internationale des Epizooties (OIE), the international veterinary organisation based in Paris. Planned by CEFAS Weymouth and INRA Jouy on behalf of the OIE, this 4 day conference included contributions relevant to the major aquaculture industries around the world. A 570 page book edited jointly by the organisers and covering all aspects of chemotherapy in aquaculture resulted (Alderman, & Michel 1992; Michel & Alderman (editors) 1992).

At about the same time the International Council for the Exploration of the Sea (ICES) created a new working group on the Environmental Impact of Mariculture. One of the major remits of that group was to produce an extensive report on the effects on the use of chemicals (principally antibiotics) in aquaculture on the environment (Alderman, 1994).

Looking back to those two overviews (OIE and ICES) it is clear that the concentration of interest towards the problems of the use of chemotherapeutants, mainly antibiotics, was already beginning to change. The regulatory changes associated with the creation of the open market within Europe were underway had begun to affect the way in which veterinary medicines were approved in Europe. The 'MRL Regulation' had just been published and work was going on towards the development of formal residue monitoring programmes for fish meat. Again CEFAS expertise in this area was called upon in suggesting ways in which a monitoring programme for veterinary medicines residues in fish might be developed which offered good consumer protection whilst minimising the costs. Preliminary programmes were set up by Veterinary Medicines Directorate following the outlines produced by the expert group which helped to inform us when full scale monitoring was discussed some years later.

In the early 1990s the rebuilding of the Weymouth laboratory meant that for more than four years little work could be carried out with fish because of very limited availability of tanks for experimental work. Efforts were therefore again concentrated towards the potential for adverse environmental effects and in particular on the risks of transfer of antibiotic resistance beyond the aquaculture environment. A combination of laboratory and field work led us to the view that, in developed countries with adequate water treatment systems the probability of resistant bacteria from aquaculture having any effect on bacteria pathogenic to humans was remote in the extreme.

Other aspects of the changes of regulation of veterinary medicines which began to come into effect ten years ago also seemed likely to have an adverse effect on the availability of antibiotics for use in aquaculture. Aquaculture is, except perhaps in Norway, a small market, relative to large animal land farming. It was thus unable to support the costs of gaining and even for retaining marketing approval for many pharmaceuticals under the tightened legislatory framework associated with the open market, except for well-established products. These are products for which in effect only the 'additional' safety and efficacy data for use in the aquatic environment were required for approval. Research plans were therefore developed that would be implemented when the new laboratory facilities became available, to look at ways in which the few available antibiotics might be used more effectively. This overview will continue in the next edition of Trout News.

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STOCKING – LOOKING TO THE FUTURE

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Trout fisheries are important. Our research indicates that each year, about a quarter of those holding an Environment Agency rod licence holder fish for trout in England and Wales. In 2000, they spent over 3 million days fishing for brown or rainbow trout, with 1 million days on rivers and 2.6 million days on still waters. Their expenditure of hundreds of millions of pounds each year helps support many jobs. Fishing rights for trout are worth £600 million, about five times the value of salmon fishing rights.

Stocking is also important. The average catch per day is a key factor determining the market value of fishing rights for trout. For most stillwater fisheries and many river fisheries, the catch depends on stock fish – highlighting their importance. But wild trout are also valuable. On river fisheries another significant factor determining value is the proportion of wild trout in the catch. This is not surprising given how anglers value wild trout.

In a survey of rod licence holders in April last year, there was a very clear preference amongst trout anglers, other than youngsters, to fish for wild trout rather than stocked fish. They mostly caught stocked trout, reflecting availability. Of course, it is not simply a choice between wild and stocked trout. In most fisheries, particularly still waters, it is stocked trout or nothing. But if we can improve the quality of fishing for wild trout where it exists, and also have fishing for stocked trout available, this would offer the best of both worlds.

In July last year we issued a consultation document on a National Trout and Grayling Fisheries Strategy. Although the consultation closed in October, the paper is still available on our web site www.environment-agency.gov.uk/fish.

The aim of the Strategy, is:

'to conserve wild stocks of trout, sea trout, char and grayling, and their environment, whilst enhancing the social and economic benefits derived from all types of fisheries for these species in England and Wales.'

Please note that the Strategy does not only consider wild trout. It is a fisheries strategy – that means it is not just about fish conservation but recognises the economic, social, and indeed environmental importance of fishing. Secondly, we are concerned with all fisheries whether for wild or stocked fish, in rivers or still waters.

Although we had already consulted widely, including the trout farming industry, we wanted to hear people's views; we were not presenting a final strategy.

Two year old triploid brown trout reared at Allenbrook Trout Farm: January 2002

Stocking is only one issue covered in the Strategy but it was the issue most frequently mentioned in responses to the consultation. In particular, respondents commented on the proposed classification of trout fisheries. Linked to this, some concerns were expressed about extending the use of triploid brown trout for stocking in fisheries with a significant population of wild trout (that is where trout breed naturally).

So why should we need to use triploids? Is there any reason to think that stocking poses a threat? In its evidence to the Government's Salmon and Freshwater Fisheries Review, the Moran Committee, representing all the national angling bodies, stated that:
'wild brown trout in these waters (upper reaches of lowland rivers) are probably the most at risk, not only through displacement by stocked fish, but also by interbreeding with stocked fish endangering the genetic integrity of native populations'.

Subsequently, the Moran Committee 'strongly' supported the Review Group's recommendations on stocking, including:

- *'stocking should be allowed only where there is no significant risk of ecological detriment ….. and where there is a demonstrable environmental, economic or recreational advantage;'*
- *'stocking should not normally be permitted in waters with established fish populations where it is not currently practised and has not been practised in recent years.'*
- *'where stocking is consented: the size, age, number and provenance of the stocked fish should be appropriate to the ecological characteristics of the receiving water'.*

Leaving aside other potential impacts of stocking, there is interbreeding to consider. We know for trout, as for salmon, that stocking farm-reared fish can alter the genetic make-up of a wild population. Since we are concerned about retaining the local characteristics of our wild stocks, then stocking needs careful management. More difficult to demonstrate is to what extent the fitness of the wild population will be affected. The weight of scientific opinion is that there is a significant risk under some circumstances, though not everyone agrees. A recent report on the genetic management of brown trout may be of interest:

Laikre *et al*, (1999) Conservation Management of Brown trout (*Salmo trutta*) in Europe.

It is available from:
www.qub.ac.uk/bb/prodohl/TroutConcert/TroutConcert.htm

The Agency believes that the Precautionary Approach should be applied to the protection of genetic characteristics and fitness of wild trout populations. This national and international environmental principle is defined as:

'Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation'. Rio Declaration 1992.

In the case of stocking fertile, farm strain trout into waters with significant wild trout populations we accept that:

- such stocking poses a threat of irreversibly changing the genetic composition of the wild stock;
- these changes pose a risk to the fitness of the wild population in the stocked fishery;
- there is a lack of full scientific certainty on the level of risk; and
- if there is an effective way of avoiding the risk without imposing significant costs overall on fisheries interests then we should adopt it.

We have therefore proposed that for stocked waters which contain significant populations of wild trout (produced by natural reproduction), stocking should be either with:

- all-female triploids (sterile); or
- given an appropriate rearing regime, offspring of local, wild broodstock.

For other waters, including the majority of stillwater fisheries there would be no such constraints, although triploids may well be stocked there for other reasons. Most stocked trout go into still waters and are rainbows. We understand from the British Trout Farmers Restocking Association that the majority of rainbow trout stocked are triploid.

The 'triploid' solution for wild fisheries arose as a possibility after informal discussions with national angling, fish farming and conservation interests. A review was commissioned from Dr. David Solomon of the potential for restocking using all-female triploid brown trout to avoid genetic impact upon native stocks, which was encouraging. The review is available on the Agency's web site (see above).

The Strategy recognises that the issues surrounding triploids are complex and that wider experience of all-female triploids is needed before fully implementing this policy. Two stages are therefore proposed:

Phase 1 (2002-2005): Where stocking is consistent with practice over the past five years, the Agency would not refuse consent to stock fish because of any potential genetic impact though it would recommend the use of female triploids or, if appropriate, the offspring of local broodstock. Where the intention is to increase stocking levels, then the additional stock must comply with the policy.

Phase 2 (2006 onwards): Subject to a review of triploid performance, based on Phase 1 and including extensive consultation with fishery interests, the policy would be fully implemented.

As yet the Agency has not yet adopted this policy. We are still considering the responses to the consultation. Nonetheless, if it were to be adopted it is clear that further research is needed during Phase 1 before Phase 2 could be implemented. This research would have to cover a range of subjects including factors which might affect production of triploids; their performance in fisheries; and how they interact with wild trout populations. We would need to work with others, including trout farmers, to complete this research.

So how will the Strategy be taken forward? There is broad, though not universal, agreement amongst fisheries interests on many of the Strategy's proposals for stocking, including that:

- stocking can impact on wild trout populations;
- a consistent national framework for regulating stocking is needed, taking account of the potential impact of stock fish on the genetics of wild trout; and
- local fisheries interests must be consulted in the application of this national framework.

We are considering how the Strategy should be changed in response to the consultation and need to clarify the views of some national bodies on certain points. We will then be seeking the approval of the Agency's Board for a final, revised Strategy later this year.

SELECTIVE IMPROVEMENT OF RAINBOW TROUT

Brendan McAndrew, Institute of Aquaculture, University of Stirling, Stirling, Scotland, FK9 4LA

Selective breeding has resulted in massive improvements in the commercial characteristics of the vast majority of farmed animal and plant species. Many of the strains we see today were well established before breeders knew about the genetic mechanisms that control the inheritance of commercial characters. Farmers have intentionally and unintentionally, over many hundred of years, changed the nature of the strains by breeding from the individuals that best suited their requirements. We see this today in the many different land races of sheep, cattle, pigs and poultry world-wide. In the past 40 years the rate of improvement has accelerated as the science of genetics has developed and has given us an insight into the mechanisms controlling these traits. The continual improvements in quantitative genetic theory and the expansion of computing power have improved the efficiency of breeding programmes. One such example is the yield of meat from chickens which has increased by 300% in the last 30 years. Today broiler chickens are harvested at around 2kg after about 35 days of growth.

With the obvious and continuous benefits that come from selective improvement programmes why have so few been initiated in farmed fish? It is very clear from economic studies undertaken in Norway that their salmon improvement programme is very cost effective. The annual cost is only about 7% of the of the value of the improved production resulting from the genetic programme (Gjedrem 1991). Aquaculture is still a relatively new activity and the farmers involved have had to overcome many different biological, husbandry and technical problems in order to establish a viable industry. The choice of strain and its genetic management have not been major issues as long as production and profits have been reasonable. The industry has grown by increasing intensification or by expansion of the number of farm sites. It is only in recent years as the industry has matured and margins have contracted that improving efficiency by genetic methods has been discussed. One-off genetic improvements, such as single sex populations or sterility, have been widely applied in many species and have helped to maintain profitability. However, despite increases in productivity of around 20% for such manipulations the baseline productivity of the strains used has remained stable or decreased as the genetic basis of the stocks have been degraded by a lack of any genetic management.

UK rainbow trout

Despite the fact that the rainbow trout is probably the most scientifically studied of all fish species very little of this knowledge has been applied to the culture of this species. In the UK, and the world generally, rainbow trout eggs have become a cheap commodity, as producers continue to try to reduce costs, so removing any incentive by the hatcheries to improve the quality and add value to the seed being produced. On average Atlantic salmon eggs are sold for £50/1000 compared to the £5-10/1000 commonly paid for trout. The whole industry would benefit if the few hatcheries supplying eggs could recoup the cost of improvement by charging a small premium for eggs that would more than be covered by their subsequent enhanced commercial performance. A feedback loop between ongrower and hatchery would ensure that the improvement was in the traits chosen by their customers so they could see the direct benefit of this activity.

All hatchery managers have to make a decision on the fish they want to keep as future broodstock. It is how informed that decision is that will have a profound effect on the future performance of the fish derived from that strain. This is not as simple a process as it might first appear because fish are cold–blooded and are therefore much more susceptible to environmental fluctuations. Small initial differences in the age or size of fish or small differences in the conditions between tanks or ponds can make it very difficult to accurately compare the performance and therefore estimate the genetic value of different fish. Even if great care has been taken to minimise all extraneous sources of variation that might mask genetic values a hatchery manager cannot be certain of the genetic relationship between the fish eventually selected or how many different families of fish are represented in the broodstock? Related mating or inbreeding can rapidly degrade the viability of any small closed hatchery population. Brother/sister (full-sib) mating results in a high level of inbreeding (25%) and can reduce commercial performance of affected offspring by an average of 20% in rainbow trout (Kincaid 1983), a much greater reduction in performance in a single generation than any expected gain possible through a selective breeding programme!

Norwegian model

The few breeding programmes that have been established for fish are based on the Norwegian family selection model. The offspring from single pairs (family) are kept in separate tanks until they are large enough to be tagged. The tagged offspring from each family are then split into groups, some are retained on site as future broodstock and the remainder are sent to commercial sites so that their performance can be assessed for a number of commercial and quality traits. This information is used to identify and rank the best families under commercial conditions. The individual and family performance of the potential broodstock are also assessed and the combined data set is used to identify best individuals from the best families as the next selected generation. The level of inbreeding can be accurately controlled and minimised as the programme has pedigree data on all fish over several generations. This approach has been shown to work and estimated gains over 8 generations are in excess of a 100% increase in growth rate. Although a highly effective method of improving performance the application and cost of such a family breeding programme makes it only feasible for nationally-funded breeding programmes or for large well established companies.

New technology

If genetic management and selective improvement are to become more widely used then a cost effective alternative is needed. The major cost is the tank facility needed to maintain individual families separately until they are large enough to be physically tagged. This alone has obviously dissuaded many companies from even attempting to start a programme. For some mass spawning species such as seabream and bass it is not even possible to produce single families or even know the genetic makeup of the offspring produced. Genetic tags have been seen as a way of overcoming some of these problems as every individual will carry its own unique genetic fingerprint. However, it is only in the last few years that geneticists have had access to suitable highly variable genetic markers and quick and cost effective ways of visualising them. These genetic fingerprints, based on highly variable microsatellite loci, are effectively unique for every individual but are inherited in a simple Mendelian fashion. This means that if we know the fingerprint of the parents then we can accurately identify the fingerprint of their offspring. All that is required is a small sample of tissue, piece of fin, scale or drop of blood, which can be taken at anytime in the animals life-cycle. The cost of fingerprinting is being reduced every year and a number of companies are now offering this service to the aquaculture industry.

Novel breeding programmes

This technology now opens up many different possibilities for the design of breeding programmes independent of the infrastructure required for a family unit or the different biological problems posed by some species. Large commercial sized populations of fish made up from many different families from fingerprinted parents can be allowed to undergo normal farm production and the best fish identified at the time of harvest. If these fish are to be used as future broodstock they can be physically tagged for future identification and a small sample removed for fingerprinting. The farmer can then be given information on how many different families are represented in his replacement broodstock and which fish can and cannot be mated on the basis of their relatedness. Such a procedure enables the farmer to maximise the genetic gain and minimise any potential inbreeding. This simple model works best for simple phenotypic traits with a high genetic component such as growth rate. More complex designs are needed to improve post harvest traits (e.g. fat, flesh colour) or when selecting for disease resistance which will rely on breeding from the relatives of the fish that had to be sampled. These techniques are now being applied to a wide range of different species world-wide including Atlantic salmon, coho salmon, halibut, seabream, seabass, tilapia and various Asian carp species. This is leading to the first fish selective breeding companies being established following the developments seen in other species that resulted in such dramatic improvements.

LINK Project

The LINK Aquaculture project on the genetic improvement of UK rainbow trout is a collaborative project between the British Trout Association and some of its member farms with scientific input on molecular markers and quantitative genetics from the Institute of Aquaculture and the Roslin Institute. The project will help to identify breeding goals that will have the greatest economic benefit to the industry. Breeding experiments using UK strains will identify what traits will need to be included in any selection index adopted by the industry. Specially constructed populations containing equal contributions of many families will enable details of the levels of genetic variation present in the UK strains to be established and the likely success of a selection programme based on the initial breeding goals. A wide range of existing salmonid microsatellite loci have been tested and are presently being analysed to see which are the most informative for parentage assignment in UK strains. The availability of cost effective genetic fingerprinting will enable individual hatcheries to establish their own breeding programmes best suited to their own or their customers requirements. The project will also help to develop protocols so that a feedback loop on genetic performance can be established between the hatcheries and their customers. Getting feedback has become more difficult as the industry has become more and more niched with egg producers (national and international) selling to fingerling producers who then sell to ongrowers. The individual performance of any fish becomes more blurred as it is mixed with other fish of the same or different strains and ages at each grading as it moves through the production process. The project will help to design protocols that will enable the genetic value of individual fish to be determined under commercial conditions.

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DEFRA/BTA FUNDED RESEARCH

LINK AQUACULTURE – TROUT RELATED R&D

Compiled by Dr Mark James of LINK Aquaculture

The Committee for Aquaculture Research and Development or CARD was established as a forum for industry to discuss its research and development requirements with Government. During the life of the LINK Aquaculture programme, the work of CARD and LINK was dovetailed such that some of the research priorities highlighted through CARD were addressed as collaborative research and development projects funded by LINK. Over the five year life of the LINK programme, this process became well refined, to the extent that the programme's sponsors, DEFRA, NERC and SEERAD worked together to ensure that funding was available to take forward worthy projects in a number of areas of R&D prioritised by the industry. Members of the research community were encouraged to engage the various industry associations to flag up research opportunities and, by the same token, industry developed their R&D portfolios based on sound scientific advice. As the programme evolved, it became clear that Government sponsors were more inclined to fund projects that had support at the industry association level, thus ensuring that project results would have a wide audience and address significant sectoral issues.

At the most recent CARD gathering in November 2001, the structure and format of the meeting was modified to reflect the significant changes in the R&D funding environment that have occurred since the decision not to support a second LINK programme was taken in November 2000[1]. Since that time it has become clear that much applied aquaculture R&D will need to be taken forward on a thematic, rather than sectoral basis. In practice, this means that money to support applied R&D will need to be sought from a far more diverse range of funding agencies. By definition, aquaculture projects will have to compete for funds with other terrestrial or more conventional agri-industry and food industry proposals.

Under the new arrangements for CARD, the various industry associations including the British Trout Association, were charged with seeking consensus amongst their membership on R&D priorities and then formally presenting these to a broad range of potential sponsors attending the CARD meeting. The idea being that each sponsor would, at the very least, be made aware of what R&D was needed, and be in a position to convey this information to the various committees and subgroups they administer. It remains to be seen if this approach will yield the focused and co-ordinated R&D that is required, but at present CARD is the only mechanism available to promote the industry's R&D requirements.

The climate for aquaculture R&D funding both within the UK and Europe is looking somewhat bleak for the next 12 to 18 months at least. In Europe, the Fifth Frame work programme, a major sponsor of pan EU projects, is coming to a close and, although the details of the Sixth Framework are still unclear, rumour suggests that funding for aquaculture will be far more restricted. In the UK, devolution has emphasised differences in funding priorities for aquaculture north and south of the border. Respective Government departments still tend to favour investing the lions share of their R&D resources into their various agency laboratories. Universities and other research institutes rely principally on Research Council funding.

The Scottish Executive is developing an aquaculture strategy involving a wide ranging consultation process and is due to report in Spring/Summer 2002. As part of this process, it is important that the need for a properly resourced and diverse R&D infrastructure is given full consideration. Access to world class R&D is required to underpin the strategic and sustainable development of aquaculture in the UK. It is vital that politicians, senior administrators and the industry have a clear and realistic understanding of the resources required to cultivate and maintain the appropriate expertise.

There is a worrying trend for the funds available for R&D to become increasingly fragmented, with ever-smaller sums available for shorter time periods. Opportunities to match funds with additional sponsors are often a logistical and administrative nightmare, with respective funding bodies all operating their own, often idiosyncratic, application, assessment and contractual procedures. The same level of administration is often applied to the allocation of £5k as for £50k or indeed £500k in some sectors!

[1] BBSRC still accepts stand-alone LINK applications.

The UK has an exceptional international reputation for aquaculture related R&D. As such, this sector of the UK science base should be recognised and valued as an important part of the UK's knowledge-based economy. In part, this process requires culture change amongst members of the academic scientific community. Scientists must learn to communicate effectively with industry. Science must also adopt more creative and applicable measures of excellence when judging the merits of individuals or proposals than conventional measures such as citation indices and number of academic publications.

At the last International Fish Farming Exhibition in Glasgow in 2000, participants in the LINK Aquaculture programme staged a highly successful one-day Conference. With almost half the projects completed and the remainder due to finish by 2003, the main objective of the Programme is now to ensure that the results of LINK projects reach the widest possible audience within the industry and that results emerging from projects are taken forward. With this in mind we will stage a major display of LINK work at the forthcoming International Fish Farming Exhibition at the SECC in Glasgow - 18th - 20th April 2002.

A poster display of trout related LINK Aquaculture projects has been presented over the last two years at the British Trout Farming Conference at Sparsholt. This display has been well received by the industry and has helped to ensure that key members of the industry are aware of the latest scientific developments. We plan to stage a similar event in Glasgow including all LINK funded projects. To augment the poster displays we are exploring the potential to provide rolling audio-visual presentations, together with static displays of some of the 'hardware' and 'software' that has been developed through LINK projects.

Entry to the exhibition will be free of charge. It is likely that this event will represent the largest and most comprehensive display of UK aquaculture related R&D ever presented. Each presentation will be accompanied by detailed summary sheets for delegates to take away.

Six LINK trout related projects have now been completed and their outcomes are summarised in brief below. More detailed information for ongoing studies has been provided by the project leaders.

Dr Mark James
Programme Co-ordinator

Completed Projects - conclusions:

PYCEZE an alternative to Malachite Green – TRT01

Project Leader: Mr Julian Braidwood, Novartis Ltd
Sponsor: DEFRA
Research Partners: Novartis Ltd; CEFAS; IFE
Industrial Partners: Scottish Quality Salmon; British Trout Association

Novartis Animal Vaccines Ltd (NAVL) was granted a UK Provisional Marketing Authorisation for Pyceze in July 2001, for the treatment and prevention of saprolegnia on salmonid eggs. It has an Annex II entry (Directive 2377/90, no Maximum Residue Limit required) which we anticipate will be extended to include all finfish. Pyceze is authorised for use in Norway and Faroe Islands and is being trialled in Chile, North America and Ireland. A dossier will be submitted early in 2002 for a full marketing authorisation for fish and eggs. EU wide authorisation will be pursued through the Decentralised (mutual recognition) Procedure.

This is the culmination of many years of work, supported initially by the LINK funding scheme, and finally makes available an authorised medicine in place of malachite green.

Further Information is available from:
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Identification and Assessment of Chemical Control Methods for PKD -TRT04

Project Leader: Dr Sandra Adams, Institute of Aquaculture, University of Stirling
Sponsor: DEFRA
Research Partner: University of Stirling
Industrial Partners: Vetrepharm Ltd; Aquaculture Vaccines Ltd; British Trout Association

Proliferative kidney disease (PKD) continues to affect many trout farm sites in the UK annually. This project identified two compounds as potential chemical treatments for PKD. One of the compounds was shown to directly affect the survival of *Tetracapsula* *bryosalmonae* (formerly known as PKX) *in vivo,* while the other compound appeared to delay the infection or reduce fish mortalities (due to PKD and co-infections). Large-scale trials were conducted with this latter, naturally derived compound, and demonstrated that it had a measurable effect in reducing the mortality on enzootic farms. However, this effect was slight and appeared to be involved in enabling the fish to respond better to other stressors rather than PKD itself.

The other compound was shown to be effective in removing *T. bryosalmonae* from rainbow trout, however, relatively high doses of the chemical adversely affected the haematopoetic tissue. A six day treatment with the compound at a level of 100mg/kg of feed administered at 1% body weight per day appeared to remove all of the parasites from a moderately infected kidney while preventing high mortalities, although adverse effects were still observed. The timing of the treatment was also important in the successful administration of the compound. Those fish that were fed when they possessed pre-clinical PKD (grade 1 kidneys) all recovered from the disease, however, feeding fish during the clinical stages of the disease had little effect in reducing the parasite numbers. It was also noted that those fish that were successfully treated with the compound became re-infected with the parasite later in the summer. This may be significant in allowing the fish to obtain natural resistance to the parasite while avoiding the disease though the height of the summer. Data from recent field trials is currently being analysed to confirm the optimum dose and timing for the treatment of PKD.

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Development of Vaccination Methods for the Control of BKD – SAL10

Project Leader: ***Dr Sandra Adams, Institute of Aquaculture, University of Stirling***
Sponsor: ***DEFRA***
Research Partners: ***University of Stirling; University of Plymouth***
Industrial Partners: ***Aquaculture Vaccines Ltd; Scottish Quality Salmon; British Trout Association***

Bacterial kidney disease (BKD) is a chronic bacterial disease affecting both wild and cultured salmonid fish. The development of an effective BKD vaccine would be extremely useful but so far has not proved possible using conventional methods. This project took an alternative approach and used biotechnology to develop a recombinant vaccine. Individual *Renibacterium salmoninarum* antigens were identified and synthesised in bulk in the laboratory by scientists at the University of Plymouth. These recombinant vaccines were then tested for efficacy at the Institute of Aquaculture, University of Stirling, with the British Trout Association, Scottish Quality Salmon and Aquaculture Vaccines Limited (AVL) participating as industrial partners on the project.

A total of seven different *R. salmoninarum* recombinant antigens were produced and tested for toxicity, efficacy and immune response. Aquarium trials confirmed the immuno-suppressive nature of the P57 protein and indicated that four of the recombinant antigens stimulated a protective immune response in Rainbow trout. Two of the antigens were also tested in Atlantic salmon and showed protection. These promising recombinant vaccines will be tested in the near future in field trials.

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Martyn Gilpin[2], Colin Munn[2],
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University of Plymouth, Plymouth PL4 8AA

Assessment of chemical and potential immunological control methods for *Ichthyophthirius multifiliis*: Chemical methods - TRT06

Project Leader: ***Dr Rodney Wootten, Institute of Aquaculture, University of Stirling***
Sponsor: ***DEFRA***
Research Partners: ***University of Stirling; University of Plymouth***
Industrial Partners: ***British Trout Association; Novartis Ltd; Scottish Quality Salmon***

Six in-feed compounds were tested both in the protection they might provide prior to and when infected with the parasite whitespot, *Ichthyophthirius multifiliis*. Of the compounds tested, salinomycin sodium appeared to be the most efficacious. Three separate trials with infected fish fed a targeted dose of 100 ppm salinomycin sodium, for 10 days ingested 38 ppm, 43 ppm and 47 ppm of the medicated diet which, significantly reduced trophont numbers by 80%, 72% and 93% respectively. Trials using a lower target dose (50 ppm) or a shorter period of drug administration (5 days) reduced efficacy.

These results indicate that salinomycin sodium is an effective treatment for *Ichthyophthirius multifiliis* when given at the nominal dose of 100 ppm for 10 days.

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Automated Humane Slaughter of Trout – TRT07

***Project Leader:* Mr Jeff Lines, Silsoe Research Institute, Bedford**
***Sponsor:* DEFRA**
***Research Partners:* Silsoe Research Institute; Bristol University**
***Industrial Partners:* British Trout Association; Humane Slaughter Association; Aquatess Ltd; Waitrose Ltd; Tesco Stores Ltd; Safeway Stores plc; Marks and Spencer plc; Sainsburys Supermarkets Ltd.**

This project formally ended in October. The research has resulted in guidelines for electric stunning of trout meets the trout industry requirements for both welfare at slaughter and carcass quality. A harvesting machine has been built to demonstrate one way of achieving this. The machine was demonstrated to members of the trout industry at Test Valley Trout in November provoking substantial interest. Two manufacturers have identified themselves as interested in building and marketing such a unit. A second demonstration of this machine is being arranged by the Humane Slaughter Association on 6th February 2002 in the Scottish Borders. For further information please contact the project leader Jeff Lines (tel. 01525 860000; email Jeff.Lines@bbsrc.ac.uk).

Dave Robb[1] and Jeff Lines[2]
[1] DFAS, University of Bristol, Langford, Bristol BS40 5DU
[2] Silsoe Research Institute, Wrest Park, Silsoe, Bedford MK45 4EY

Project progress summaries:

Investigations into immune responses to RTFS, with a view to disease control - TRT 10

***Project Leader:* Professor Randolph Richards, Institute of Aquaculture, University of Stirling**
***Sponsor:* DEFRA**
***Research Partner:* University of Stirling**
***Industrial Partners:* Vetrepharm Ltd; British Trout Association**

Rainbow trout fry syndrome (RTFS), caused by *Flavobacterium psychrophilum,* continues to be one of the most significant diseases affecting the rainbow trout fry and fingerling industry in the UK. This project, now in its final phase, aims to develop an effective RTFS vaccine. The research is being performed at the Institute of Aquaculture, Stirling University in collaboration with Alpharma Animal Health and the British Trout Association.

A variety of potential vaccines have been tested in Rainbow trout to assess their immune response and to identify the optimal method of vaccine preparation. The data indicated that fingerlings mounted a rapid antibody response to *F. psychrophilum* antigens and significant protection was achieved with some of the vaccine formulations following challenge. In addition, passive immunisation studies, whereby naïve fish were injected with serum collected from fish that had been exposed to RTFS and then infected with *F. psychrophilum,* also showed that protection could be conferred and provided evidence of the involvement of antibodies in protection against RTFS. Alternative media for the culture of *F.psychrophilum* that avoid the use of beef products have successfully been developed and numerous vaccine preparations are now currently being tested in aquarium trials to confirm which preparations should then be taken to field trials.

Ruth Campbell, Kim Thompson, Sandra Adams and Randolph Richards
Institute of Aquaculture, University of Stirling, Stirling, FK9 4LA

Selective improvement in rainbow trout: mass selection and markers - TRT12

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

This project officially started on the 1st June 2001 with the part-appointments of Dr Neil Cameron, a quantitative geneticist from the Roslin Institute with extensive experience in the development of breeding programmes in the pig industry, and Dr John Taggart of the Institute of Aquaculture, a molecular geneticist with many years of experience working on trout and salmon. They both attended the first project meeting along with Professor Niall Bromage, the technical Director of the British Trout Association, the two Principal Investigators, Professor Brendan McAndrew and Dr John Woolliams and Mr Jóse Pedro Ureta, an MSc research student at the Institute of Aquaculture who will be involved in the molecular marker work on the project.

The projects stated objectives are to identify breeding goals and produce a selection index for the UK rainbow trout industry. A number of visits to different farms, hatcheries, and processing facilities over the past few months has helped all involved to develop an in-depth understanding of the requirements of the different sectors before a more wide ranging survey of the industry's requirements is undertaken. This will be backed by detailed breeding experiments to assess the levels of genetic variation and the genetic correlations between performance traits in some of the most important UK rainbow trout strains. This work will be carried out under commercial conditions and will utilise the latest (Passive Integrated Transponder (PIT)) tagging and DNA fingerprinting techniques to identify the genetic relationship between individual fish.

John Taggart and Jóse Ureta have already identified and analysed a number of highly variable DNA microsatellite loci (genetic fingerprinting) in three widely used UK rainbow trout strains. They have developed a protocol that will enable a number of these loci to be assessed simultaneously enabling individual fish to be assigned to a single family in large commercial populations. This will require no more than a tiny sample of fin tissue and uses the Polymerase Chain Reaction technology to amplify the amount of the required DNA for subsequent analysis. The samples from individual fish are analysed on a semi-automatic gene sequencer system that turns the genotype data into a format suitable for subsequent parentage analysis by computer. This system allows relatively large numbers of fish to be analysed in a short period. This means that we can work with large numbers of eggs coming from many different families combined into a single commercial sized population. Combining the fish in this way ensures all individuals are grown under the same commercial conditions minimising environmental factors that might mask genetic differences in individual performance. The parentage of individuals selected as potential broodstock can then be assessed at or close to harvest. With this information the best individuals in the best families can be identified so that unrelated fish of high genetic value can be bred as the next generation of broodstock. This process will maximise genetic gains while minimising any problems of inbreeding in the selected lines. Various breeding designs are possible and will need to be optimised depending on the traits included in the breeding goals.

Brendan McAndrew presented a talk at the BTA conference in Sparsholt in September on the genetic principles underpinning the project and how the application of these technologies have resulted in major gains in other animal production sectors world-wide.

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

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

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

Cyanobacteria (blue-green algae) live and grow in most freshwater environments. They can produce many compounds, some of which are released into the water causing a musty/earthy taint. These taint compounds (geosmin and 2-methylisoborneol) rapidly accumulate in fish flesh imparting an unpleasant taste. Laboratory analysis (gas chromatography - mass spectrometry) allows us to detect taint compounds in water and trout. Using this technique we have determined that geosmin is the main taint-causing compound found in the UK trout tested so far. Trout samples analysed in our laboratory have shown a direct correlation between palatability in taste panel tests and the concentration of geosmin present. Microscopic analysis of the micro-organisms present in trout farms suggests that the cyanobacterium *Oscillatoria* sp. may be the causative organism. This organism is now in laboratory culture and will be investigated over the coming year.

During the course of this project we are interested in determining if water treatment methods can be used to remove taint compounds from farm water. Recently we have explored the use of titanium dioxide, a non-toxic catalyst that acts in the presence of light to bring about the destruction of organic compounds. In laboratory tests we found that this treatment method destroyed both taint compounds. Almost all (95%) of the 2-methylisoborneol was removed in 15 minutes and 54% of the geosmin was destroyed in the same time. Current studies are being carried out to optimise this treatment technology and determine both suitability and feasibility of its application in trout farms.

For further information on this project you can contact Dr Linda Lawton at l.lawton@rgu.ac.uk or write to her at the Robert Gordon University, St Andrews Street, Aberdeen AB25 1HG

INFORMATION FILE

WHERE TO GET HELP OR ADVICE

Policy Matters

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

Fish farming policy:-
Fisheries Division IIA, Room 308, Nobel House,
(Tel. 020 7238 5947) (Fax. 020 7238 5938)
Email: s.fishii@fish.maff.gsi.gov.uk

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

Research and Development Programmes:-
Chief Scientist's Group, Cromwell House Dean Stanley Street, London SW1 3JH
(Tel. 020 7904 6000) (Fax. 020 7904 6715)

You can also visit the DEFRA website at http://www.defra.gov.uk/

The National Assembly for Wales,
Agricultural Policy Division 5,
New Crown Buildings, Cathays Park, Cardiff CF1 3NQ
(Tel. 02920 825451) (Fax. 02920 823562)

Scottish Executive of Rural Affairs Department,
Pentland House, 47 Robbs Loan, Edinburgh EH14 1TW
(Tel. 0131 244 6224) (Fax. 0131 244 6313)

Department of Agriculture and Rural Development,
Fisheries Division, Annexe 5, Castle Grounds,
Stormont, Belfast, BT4 3PW
(Tel. 01232 523216) (Fax. 01232 522394)

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 http://www.cefas.co.uk

Department of Agriculture and Rural Affairs for Northern Ireland,
Fisheries Division, Annexe 5, Castle Grounds,
Stormont, Belfast, BT4 3PW
(Tel. 028 9052 3216) (Fax. 028 9052 2394)

Farm animal welfare -
Department for Environment, Food and Rural Affairs,
Government Buildings, Hook Rise South,
Tolworth, Surbiton, Surrey KT6 7NF
(Tel. 0181 330 4411) (Fax. 0181 330 8764)

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

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

Food hygiene -
Food Standards Agency
PO Box 31037
Ergon House, 17 Smith Square, London SW1P 3JR
(Tel: 0207 238 3000)

Advice on commercial activities

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

Wildlife conservation

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

English Nature,
Northminster House, Peterborough, PE1 1UA
(Tel. 01733 455000) (Fax. 01733 568834)

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

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

Other Useful Numbers

LINK Aquaculture
Dr Mark James, Marine Resource Consultants Ltd,
c/o Freshwater Fisheries Laboratory
Faskally, Pitlochry, Perthshire PH16 5LB
(Tel. 01796 472060) (Fax. 01796 473523)
E-mail: majames@compuserve.com

MINISTER LAUNCHES AWARD-WINNING LIVE FISH MOVEMENTS DATABASE

Fisheries Minister Elliot Morley visited the Centre for Environment Fisheries and Aquaculture Science (CEFAS) Weymouth Laboratory on 14 November to launch the new state-of-the-art Live Fish Movements Database.

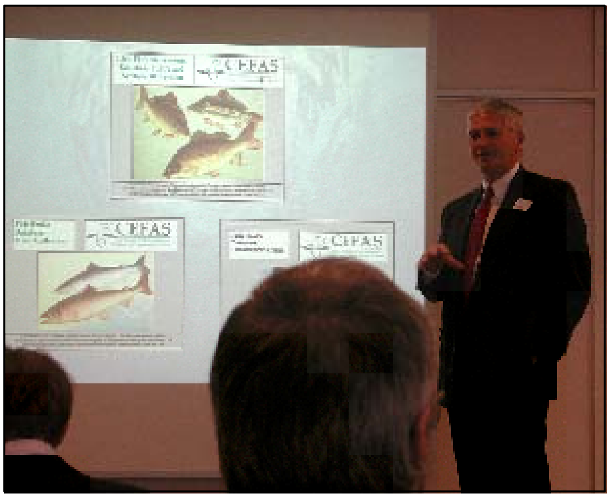
The theme for the day was '*Protecting wild fish and the environment – facilitating legal movements of fish through joint action.*'

Dr Peter Greig-Smith, the Chief Executive of CEFAS, welcomed the Minister, the press and representatives of other government agencies from Northern Ireland, Wales and Scotland. Presentations were made by Richard Cowan (head of Salmon and Freshwater Fisheries Department, DEFRA), David Clarke (head of the Environment Agency's Fisheries Department) and Eric Hudson (head of the CEFAS Fish Health Inspectorate), representing the organisations that have contributed to the development of the joint database. The project is funded by the Treasury Invest to Save Budget (ISB).

The database allows officials from the agency partners (CEFAS, EA, DEFRA and NAWAD) to view each other's records and provides a facility to monitor and regulate all live fish movements in England and Wales. It will assist in the process of identifying illegal movements, including illegal imports. It incorporates an impressive mapping system, which can highlight all fish farms, fisheries and open rivers and waters across England and Wales. In the event of a major outbreak of fish disease this facility will help in tracking the disease and in identifying vulnerable areas and premises. Records held on the database by CEFAS and the EA will enable the authorities to respond quickly and effectively to any emergency.

The merits of this project have been recognised by two awards. It was adjudged to be runner-up in the 'best joined-up service' category of the Government Computing Innovation Awards 2001, designed to acknowledge leading innovators in the electronic delivery of public services. The project was also short-listed for the prestigious ISB Progress in Partnership Awards 2001. These awards recognise schemes that show high levels of fresh, creative thinking and deliver concrete benefits, providing a model for other agencies to follow.

The Minister praised the work of CEFAS and the EA in bringing the new system into being. He also sought to draw public attention to the ongoing problem of illegal imports of live fish, which has the potential to cause immense damage to our indigenous fish stocks, and have a detrimental effect on the environment and ecology of our waters. Mr. Morley emphasised the high health status of the UK's fish stocks and added that every effort must be made to protect our fish against diseases that are common on the continent.



Eric Hudson demonstrates the database

An additional aspect of the ISB-funded project is the development of a website for business and others involved in trade and/or movements of live fish. This site (www.efishbusiness.com) was described in Trout News Issue 31 (January 2001). It has brought together for the first time all the related information on the controls that apply to live fish movements, both nationally and internationally. Information and guidance on the legislative controls and all relevant application forms are provided. Further information on preventing illegal imports of live fish is now available on this site.

The Minister chats to representatives from DEFRA, CEFAS and the EA

BTANEWS

Jane Davis, Executive Officer, British Trout Association

Quality Trout UK

Quality Trout UK, the industry's single quality assurance scheme, has seen strong support from industry players in its initial sign-up of members. Inspections for both the farm and processor standard by EFSIS have been conducted from August 2001 with some members now certified against the Quality Trout UK standards.

Quality Trout is looking to invite DEFRA officials, who supported the initial development of the scheme's roll-out, to launch the scheme to the wider media in Spring 2002.

The QTUK Technical Advisory Committee expect 2002 to provide an opportunity for continued revision of the standard and the development of an environmental code for the standard.

It is expected that all major UK retailers will require their suppliers to source trout products from farms certified against the Quality Trout UK standard.

Automated Humane Slaughter

The LINK supported R&D project, 'automated humane slaughter of trout,' has recently ended and the project's research partners demonstrated their prototype to BTA members and other project contributors at Test Valley Trout in Romsey, Hampshire in November 2001. The project's objective was to develop an affordable and safe, automatic system capable of slaughtering trout humanely while maintaining industry quality standards. In doing so the project has also established the electrical parameters that ensure current carcass quality standards. Attendees at Romsey seized the opportunity to question the researchers after their presentation of the project findings.

The value of farmed animal welfare to producers is difficult to quantify. Consumers increasingly expect that the food they purchase is guilt free, that is, produced with negligible environmental impact, to high standards of animal welfare and free from exploitation. Retailers and regulators have been quick to respond to these ethical issues, such that these concerns are likely to become minimum standards in product specification and the basis for future legislation.

As a project contributor the BTA has clearly been involved with the development of this technology and is aware of the ever increasing importance of animal welfare in all aspects of production. A second demonstration will take place in February in Moffat, Scotland. Please contact the BTA office, if you have not already done so, for further information.

Promotional Activities

The BTA's 2002 PR Campaign of generic promotion of trout has this year 4 objectives:

- Continue to shift positioning of trout towards premium-end market by focusing on added value products
- Encourage purchase and usage among target consumers
- Educate consumers on the ease and convenience of cooking with trout
- Reinforce qualities/values of trout

The proposed campaign for 2002 will be centered around National Trout Week which will take place in the Spring. The central focus of NTW is to generate media interest and national press coverage by capturing the media's imagination in our light hearted story 'British Fish Transforms British Dish' – a 'trout and chips' campaign slanted as an up-market, (amusing) and environmentally friendly alternative to the traditional 'cod 'n chips'. Rest assured, we do not expect trout and chips to become the latest product development success story!

Coinciding with other regional activities for regional press, the BTA and Hammond Communications (HC) are keen to involve BTA members in NTW by serving trout and chips during farm visits to, hopefully, regional and national food writers and by encouraging local chefs to feature trout on their week's menu.

In the second half of the year a competition focused on getting children to eat more trout (oily fish) will ask parents to nominate fussy children to a 'Trout Challenge for Small Fry'. Winners, with parents in tow, will be invited to a London venue, perhaps incorporating the London Aquarium, to attend a lunch held by our select celebrity chef to taste *and love* the specially commissioned menu.

As usual the HC press office will operate throughout the year, making the most of media opportunities to promote trout. HC are keen to learn what BTA members have planned for their promotional activity and events this year.

BTA News in Brief

AGM

The BTA has changed its financial year end to accommodate the move of the AGM to the Trout Farming Conference at Sparsholt College in September.

A short 6 month year will run from October 2001 - March 2002. The AGM held in March for the year 2000-2001 will be for accounting purposes only, as reporting of this year and the 6 month interim period will take place at the Trout Farming Conference in September 2002.

Socio-Economic Study

The Grant funded project has come to an end and it is hoped that Nautilus Consultants will be able to present their findings on the UK Trout Industry at the Trout Farming conference in September. It is the Association's aim that the project be updated on an annual basis to establish a comprehensive investigation of the socio-economic growth of the industry. It is hoped this will be of benefit not only to the BTA in its representation of the industry but also to individual members through bench marking and in assessing their business requirements.

BTA to host another Study Trip

In conjunction with BioMar Denmark the BTA are planning a study trip to Denmark in April 2002 for members of the Association. Please contact the office if you are interested in attending.

REVIEW OF SALMON AND FRESHWATER FISHERIES – GOVERNMENT RESPONSE

The independent Review Group was established in April, 1998 to carry out a fundamental review of all salmon and freshwater fisheries policies and legislation in England and Wales. The Review Group submitted its report in February 200, and the Salmon and Freshwater Fisheries Review was published in March. This wide-ranging report, containing 195 recommendations, was commented on by over 700 individuals and organisations as part of the public consultation exercise. These comments were taken into account in deciding the Government's response to the Review which was published in February, 2001.

The Government's response which follows the order that the recommendations appear in the Review can be read on the DEFRA website (www.defra.gov.uk) or copies of the report obtained, free of charge, at the following address:

Department for Environment, Food and Rural Affairs, Room 308, Nobel House, 17, Smiths Square, London SW1P 3JR (Tel: 0207 238 5933).

All comments sent to the Review Group and during the consultation exercise are open to public scrutiny unless those submitting them indicated otherwise. For an administrative charge copies may be obtained from:

Main Library, DEFRA, 3 Whitehall Place, London SW1A 2HH.

AVOIDING RESIDUES OF MALACHITE GREEN IN TROUT AND OTHER FARMED FISH

The January 2001 edition of Trout News (number 31) carried an article on page 35 about Food Advisory Committee (FAC) concerns over the continued presence of malachite green and leucomalachite green residues in a small percentage of farmed fish.

DEFRA's Fisheries Division II (David Mullin) wrote to all registered fish farmers in England and Wales together with representative organisation in September 2001 to draw attention to these concerns and to urge all users of malachite green to follow the British Trout Association (BTA) guidelines for avoiding residues in trout for human consumption. The Veterinary Medicines Directorate is responsible for monitoring residue levels in farmed fish through its surveillance programme.

Fisheries Division II are aware that the vast majority of trout farmers are already following the BTA's guidelines but there are still some small producers (and others not directly involved in producing trout for human consumption) who are not. <u>All users of malachite green are strongly advised to observe the BTA guidelines.</u> Copies of the letter from Fisheries Division II may be obtained from Pansy Barrett (Tel no: 020 7 238 5940).

CORMORANT FACT SHEET

The Moran Committee, consisting of 13 principal angling and fisheries organisations has produced a fact sheet which aims to address the concerns of fishery owners and anglers on the impact of cormorants on fish stocks. The leaflet, which was launched on December 6th by representatives of all the participating organisations, can be obtained from Louise Byrne, secretary of the Moran Committee on 020 7283 5838.

Further information can also be obtained by contacting:

In **England** –
Department for Environment, Food and Rural Affairs (DEFRA),
Wildlife Management Team, Administration Unit,
Burghill Road, Westbury-on-Trym, Bristol, BS10 6NJ.
Tel: 0845 601 4523 (local rate).

In **Scotland** -
Scottish Executive Environment and Rural Affairs Department (SEERAD),
Pentland House, 47 Robb's Loan,
Edinburgh EH14 1TY.
Tel: 0131 556 8400.

In **Northern Ireland** –
Environment and Heritage Service,
Commonwealth House, 33 Castle Street,
Belfast, BT1 1GH.
Tel: 028 9054 6558.

In **Wales** – Food and Farming Development Division 1,
National Assembly for Wales Agriculture Department,
Cathays Park, Cardiff CF10 3NQ.
Tel: 02920 825317

RESEARCH NEWS

1. Circadian timing of meal feeding

Circadian feeding time deals with the time of day of meal feeding relative to the light-dark cycle. The potential importance of circadian feeding time in fish nutrition has received an ever-increasing amount of attention with 25 reported studies on 14 species examined since 1977. In most cases the fish grew differently depending on the circadian time of feeding. This review briefly examines some of the postulated physiological mechanisms responsible for these results and also discusses the potential benefits and problems of circadian meal feeding for aquaculture. A concluding section offers recommendations for future research needs, both basic and applied.

Reference

SPIELER, R.E. (Nova Southeastern University Oceanographic Center, 8000 N. Ocean Drive, Dania, Florida 33004, USA. E-mail: spieler@nova.edu). 2001. Circadian timing of meal feeding and growth in fishes. Reviews in Fisheries Science, 9(3): 115-131.

2. Influence of fat and carbohydrate on growth under self feeding conditions

A previous study demonstrated that utilisation of carbohydrates by trout was improved by continuous feeding with an automatic feeder compared to manual meal feeding. Under self-feeding conditions where rainbow trout feed intermittently, utilisation of dietary fat and carbohydrate may be different from that under manual feeding conditions. To investigate this an 8 week feeding experiment was conducted to examine the influence of fat and carbohydrate levels in a 40% protein level diet on growth and body composition of juvenile rainbow trout under self-feeding conditions. Five fish meal-based diets were prepared to include gelatinised potato starch at four levels (9, 18, 27, and 36%) and dextrin (34%). Dietary fat levels were iso-energetically reduced from 18 to 7% by the digestible carbohydrates. Each diet was fed to four replicate groups (28 g/fish, 20 – 23 fish/group) using self-feeders. Specific growth rate, percentage weight gain and percentage protein retention did not differ between the treatments. Feed efficiency and protein efficiency ratios were higher in the 18% and 27% starch diet groups, and decreased in higher fat or carbohydrate diet groups. Although gross energy intake (kJ/kg BW per day) decreased as the starch level increased, levels of digestible energy intake did not differ between the treatments. Fat levels in the carcass, viscera and liver decreased as dietary carbohydrate level increased. These results suggest that a 40% protein diet with either 15% fat and 18% starch or 11% fat and 27% starch is appropriate for juvenile rainbow trout under self-feeding conditions.

Reference

YAMAMOTO, T. (Feed Section, Inland Station, National Research Institute of Aquaculture, Tamaki, Mie 519 – 0423, Japan. Tel: 81-596-58-6411; fax: 81-596-58-6413; e-mail: takejpn@nria-tmk.affrc.go.jp), KONISHI, K, SHIMA, T, FURUITA, H, SUZUKI, N. AND TABATA, M. 2001. Influence of dietary fat and carbohydrate levels on growth and body composition of rainbow trout (*Oncorhynchus mykiss*) under self-feeding conditions. Fisheries Science, 67(2): 221-227.

3. Use of inter-specific hybrids in aquaculture

Inter-specific hybrid fishes have been produced for aquaculture and stocking programmes to increase growth rate, transfer desirable traits between species, combine desirable traits of two species into a single group of fishes, reduce unwanted reproduction through production of sterile fish or mono-sex offspring, take advantage of sexual dimorphism, increase harvestability, increase environmental tolerances, and to increase overall hardiness in culture conditions. Hybrids constitute a significant proportion of some countries' production for certain taxa; but despite its widespread use, there is a general impression that inter-specific hybridisation is not a very useful tool for aquaculture. This impression may stem from inaccurate reporting of some useful hybrids, limited testing of strains used for hybrids, and from early work on salmonids that did not result in hybrids of commercial advantage. Experimentation with new hybrid fishes is ongoing, especially in marine culture systems where sterile fish may be preferred because of the concern that fsh may escape into the marine and coastal environment. Hybridisation has been used in tandem with polyploidisation to improve developmental stability in hybrid progeny. The results of inter-specific hybridisation can be variable and depend on the genetic structure (including the sex) of the parent fish. Inadvertent hybridisation and back-crossing can lead to unexpected and undesirable results in hybrid progeny, such as failure to produce sterile fish, loss of colour pattern, and reduced viability. Hybridisation is only one tool to improve aquaculture production and will require knowledge of the genetic structure of the brood-stock, good brood-stock management and monitoring of the viability and fertility of the progeny. Hybridisation does represent a genetic modification wherein genes are moved between different species. The implications for bio-diversity, conservation and regulation of this type of modification are discussed.

Reference

Bartley, D.M. (FIRI Fisheries Department, FAO, Viale delle Terme di Caracalla, 00100 Rome, Italy. E-mail: devin.bartley@fao.org), Rana, K. and Immink, A.J. 2001. The use of inter-specific hybrids in aquaculture and fisheries. Reviews in Fish Biology and Fisheries, 10(3): 325-337.

4. Muscle fibre density in relation to colour and texture

One advantage of aquaculture over wild fisheries is the ability to achieve some control over flesh quality which is particularly important with the ever increasing world wide production and pricing pressures for salmonid fish. The texture (firmness) of fish meat is a valued sensory characteristic for consumers and an important attribute for fillet processing. Both the connective tissue matrix and muscle fibres themselves contribute to the intrinsic textural properties of meat. Colour is also a particularly important characteristic in salmonids and it has been suggested that the variations in the number and size distribution of muscle fibres may influence the number of astaxanthin binding sites accounting for the variations in pigment concentration in different regions of the fillet. This paper examines the potential relationships between the density of muscle fibres and the colour and/or textural characteristics of the fillet. Muscle fibre cellularity was quantified during seawater growth in populations of predominantly early (strain X) and late maturing (strain Y) Atlantic salmon. The fibre density (number per mm squared white muscle cross-sectional area) in the fresh fillet was related to pigment concentration, colour as determined with the Roche *Salmo*Fan, and lipid content. The relationship between fibre density and the textural characteristics of the smoked fillet, as assessed by trained taste panels, was also determined. There was no significant correlation between astaxanthin concentration and muscle fibre density. However, significant positive relationships were obtained between Roche *Salmo*Fan score and fibre density, explaining 33% and 44% of the total variation in colour visualisation in strains X and Y, respectively. Significant positive correlations were observed between muscle fibre density and all four measures of texture assessed by the taste panels, 'chewiness', 'firmness', 'mouth-feel' and 'dryness'. A firm texture was therefore associated with a high muscle fibre density. At harvest, the lipid content of the fillet was significantly higher in strain X (11.2%) than strain Y (7.0%). There was, however, no significant correlation found between sensoric 'oiliness' score and the percentage lipid content of the fillet. The results indicate that muscle fibre cellularity is an important factor in several key flesh quality traits. The potential for manipulating muscle cellularity to produce desirable flesh quality characteristics is briefly discussed.

Reference

Johnston, I.A. (Gatty Marine Laboratory, Division of Environmental and Evolutionary Biology, School of Biology, University of St Andrews, St Andrews, Scotland, KY16 8lb, UK. Fax: +44-1334-463443; Fish Muscle Research Group: http://www.st-and.ac.uk/~fmrg; e.mail address: iaj@st-and.ac.uk), Alderson, R., Sandham, C., Dingwall,A., Mitchell, D., Selkirk, C., Nickell, D., Baker, R., Robertson, B., Whyte, D. and Springate, J. 2000. Muscle fibre density in relation to the colour and texture of smoked Atlantic salmon (*Salmo salar* L.). Aquaculture 189(3 & 4): 335- 349.

5. Effect of number of feeding days on food consumption and growth

Feeding strategies and practices have major effects on the success of culture operations, with the manipulation of feeding time, frequency of daily feeding and numbers of weekly feeding days having an influence on a range of commercial production traits. This study examined the effects of the number of feeding days per week on feed consumption, growth and feed conversion in rainbow trout. Fish of initial weight 53.6 g were held under natural winter-spring (40° 572 N) photoperiod (L:8 D:16 – L:14 D:10) and ambient water temperatures (4 - 12°C) for 128 days, and fed for 7 days per week (F7), no feeding at weekends (F5.1), no feeding on Sundays and Wednesdays (F5.2) or every other day (FEOD). Feeding treatments were replicated with 50 fish held in 200-L tanks. Number of feeding days affected final live weight, with fish in group F7 achieving a mean weight of 285.6 g, followed by F5.1 (256.6g), F5.2 (247.6g) and FEOD (223.2g). Final condition factors (CF) differed between the FEOD group and the others while feed conversion ratios (FCR) exhibited significant differences among some of the groups. The results suggest that depriving rainbow trout of feed for more than 1 day a week has a negative effect on growth, but little influence on feed conversion.

Reference

Okumus, I. (K.T.Ü. Deniz Bilimleri Fakültesi, 61530 Camburnu, Trabzon, Turkey) and Bascinar, N. 2001. The effect of different numbers of feeding days on feed consumption and growth of rainbow trout [*Oncorhynchus mykiss* (Walbaum)]. Aquaculture Research, 32(5): 365-367.

6. Effect of dietary fat level on flesh quality

The beneficial effects of dietary fat in protein sparing in salmonids is well known and it has become common practice to use high lipid levels in commercial diets. However there is evidence that high dietary lipid levels increase fat deposition in fish and alter flesh quality. This study evaluated (a) the effects of different dietary fat levels and (b) the effects of pre-slaughter feeding procedures (starvation or a low-fat diet) in sea reared triploid brown trout, which are of commercial interest in France, on growth, chemical composition, fat synthesis and deposition, plasma metabolites and sensory and physical flesh quality. Three isoproteic (crude protein content: 56%) diets with different fat levels (11%, 20%, and 26%) were fed to triplicate groups of triploid trout (initial average body weight of 1.5 kg), reared in seawater. At the end of 3 months of feeding, fish fed the high-fat (HF) diet were split into two groups: a triplicate group of fish received the low-fat diet and another triplicate group was kept unfed for a further 2-month period. Fish initially fed the low-fat diet during the first period continued to be fed the same diet. Fish fed the medium-fat (MF) diet during period 1 were eliminated for period 2. At the end of each period, comparative whole body analyses, texture and colour analysis were made on fresh and smoked fillets. During the first period, increasing dietary fat level had no significant effect on growth or feed utilisation, but increased whole body (14.6% to 17.9%, on wet weight basis) and muscle (8.3% to 11.0%) fat content. During the second period, the fish fed the low-fat diet had similar growth performance irrespective of previous nutritional history, whereas starvation led to significant loss of weight and fillet yield. Whole body fat content did not differ between groups (around 15%) at the end of period 2. In fish initially fed the HF diet, both starvation and feeding a low-fat diet led to a reduction in muscle lipid content. Sensory analyses revealed few differences between treatment, in terms of visual colour aspects, for both cooked and smoked fillets at the end of period 1. A positive relationship between instrumental colour analyses and dietary fat levels was observed, but no difference was observed for instrumental texture measurements. At the end of period 2, a significant increase in parameters of colour was observed in unfed fish. Although both feed withdrawal and feeding a low-fat diet 2 moths before slaughtering led to a reduction in fat content, starvation had the disadvantage of leading to significant weight loss.

Reference

Regost, C. (Fish Nutrition Laboratory, Unité mixte INRA-IFREMER, Centre de Brest IFREMER, 29280 Plouzané, France. Tel: +33-2-98-22-43-85; fax: +33-2-98-22-46-53. e-mail: jarzel@ifremer.fr), Arzel, J., Cardinal, M., Laroche, M. and Kaushik, S.J. 2001. Fat deposition and flesh quality in seawater reared, triploid brown trout (*Salmo trutta*) as affected by dietary fat levels and starvation. Aquaculture, 193(3 & 4): 325-345.

7. Genetic variation in growth performance

This study analysed the genetic variation in growth, carcas yield and various morphometric traits in 16 half-sib diploid and triploid families (from different sires) of rainbow and brown trout at commercial size. At 1 year old stage (300 g) in rainbow trout, and 1.5 year old stage (320 g) in brown trout (3 months after transfer to seawater), 20 to 25 fish per family were individually tagged. Individual growth performances were followed, respectively, in freshwater for rainbow trout and seawater for brown trout up to their usual commercial size of 900 g and 3 kg, respectively. In rainbow trout, a significant genetic variability was observed among families in initial body weight, length and condition factor. Mean daily growth rates of body weight during the freshwater rearing ranged from 0.70% to 0.80% between families but this difference was not significant. No significant genetic variability in final body weight (900 g) and length was observed. This was associated with an increased variability within families in these parameters and with the expression of a different genetic variability also suggested by a change in ranking between families. In brown trout, significant genetic variations in body weight, length and condition factor among families was observed at all stages up to commercial size. After transfer to seawater, a change in ranking of families for body weight was observed. These results suggest that growth performance studies should be performed at a body weight close to commercial size for 'filet portion sized' rainbow trout and large sized brown trout. At all stages, body weight, length and condition factor was significantly higher in diploid rainbow trout than in triploids. This was observed also in brown trout; diploids showed a significantly greater body weight than triploids, but no significant difference was observed in final length at 3 kg. In both species, significant interactions between ploidy and family factors was observed for body weight, length and condition factor at the initial stage studied but not at slaughtering. This result suggests that selection of diploid male breeders for growth performance would not be effective for their triploid progeny at 'pan-size' stages but effective at larger size.

Reference

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8. Development rates of clonal lines

Knowledge of the rate of development is often useful in aquaculture as this allows the culturest more flexibility in allocating space for newly hatched fry. In addition, strains of quickly developing trout might be desirable, as fast development has been associated with fewer developmental deformities, larger size, and earlier sexual maturity in some instances. The genetic basis of development rate was examined in this study using clonal lines of rainbow trout produced by androgenesis. Development rate, as indicated by physiological time to hatch in degree days was examined in four clonal lines crossed to outbred females in three separate experiments. In the first experiment, the Swanson line, derived from an Alaskan population, displayed a significantly earlier physiological time to hatch than the Arlee line, derived from a domesticated rainbow trout. In the second experiment, this trend was maintained across three temperatures (approximately 8, 10, and 14°C) and two females, although the experiment lacked the statistical power to detect a difference. In the third experiment, the Swanson line had a significantly earlier physiological time to hatch than three other clonal lines when tested across three temperatures (8, 10, and 16°C) and two females. There was no evidence of genotype by environment interaction in any of the experiments. These data indicate that development rate has a strong genetic component, and that the clonal lines of rainbow trout available should be highly suitable for quantitative trait locus analysis of development rate in rainbow trout. This technique, which has been successfully used for the genetic improvement of domesticated plants and livestock and the identification of the genetic basis of traits important in human medicine using mice remains largely un-exploited in aquaculture.

Reference

Robison, B.D. (Department of Zoology, Washington State University, P.O. Box 644236, Pullman, WA 99164-4236, USA. Tel: +1-509-335-1526; fax: +1-509-335-3184; e-mail: brobison@wsunix.wsu.edu), Wheeler, P.A. and Thorgaard, G.H. 1999. Variation in development rate among clonal lines of rainbow trout (*Oncorhynchus mykiss*). Aquaculture, 173(1-4): 131-141.

9. Selective angling of introduced brown trout

For almost a century brown trout populations throughout Europe have been affected by stocking hatchery reared trout of unrelated genetic origins to boost natural populations. This has resulted in many natural stocks becoming endangered by introgressive hybridization with introduced trout. In addition to this natural stocks have also to cope with recreational angling affecting both the size frequency and overall population size, leading to overexploitation and possible extinction. This study focussed on the impact of angling on a stocked brown trout population in the river Doubo, Switzerland, containing an indigenous stock of Mediterranean brown trout. The study assessed the hypothesis that angling acts as an important selective force against introduced Atlantic trout and their hybrids and thus is a major factor responsible for the low introgression rate observed in the Doubs trout population. Comparisons of the genetic composition of trout captured by anglers and by electrofishing based on three diagnostic microsatellite loci provided strong evidence that angling is selective in a stocked brown trout population. At two sites, anglers caught significantly younger trout and proportionally more introduced hatchery trout and hybrids than were observed in electrofishing surveys. Selective angling, in combination with a small legal catch size, may have considerably eliminated introduced trout and hybrids before spawning at the study sites, and thus may have reduced the introgression of alien genes into the local gene pool. Angling can be an important factor influencing the genetic structure of fish populations and should be taken into account in studies of introgressive hybridization in stocked fish populations and their management. Demographic consequences of stocking were not assessed in this study. Thus, even though the genetic consequences of stocking may be minimal or largely reversible through angling, resource competition between native and introduced trout, until they reach legal catch size, is expected to have a negative effect on the productivity of the indigenous trout population.

Reference

Mezzera. M. and Largiadèr, C.R. (Division of Population Genetics, Institute of Zoology, University of Berne, Baltzerstrasse 6, CH-3012 Berne, Switzerland. Tel: +41-31-631-45-13; fax: +41-31-631-48-88; e-mail: largiader@zoo.unibe.ch). 2001. Evidence of selective angling of introduced trout and their hybrids in a stocked brown trout population. Journal of Fish Biology, 59: 287-301.

10. Diet self selection

Few studies have been carried out on selectivity and preference for nutrients in fish due to the complexity of providing feeds differing in nutrient content in an aquatic environment. However, recent advances in self-feeding devices for fish have enabled work in this field to progress. This study investigated the selectivity of rainbow trout to diets containing different protein amino acid balances and protein levels on fish housed individually using self-feeders. Semi-purified diets with (1) a high protein (crude protein; CP = 40%) and a balanced amino acid profile (casein:gelatin = 6:1, BAL), (2) a high protein and an imbalanced amino acid profile (1:6, IMB), (3) a low protein (CP = 15%) and a balanced amino acid profile (LP), and (4) a protein-free diet (PF), were examined using self-feeders. In experiment l, combinations of two diets (BAL and IMB; BAL and PF; IMB and PF) were used. For each combination, four individually housed trout were provided with the diets. After an initial 2-week period, the positions of the two feed containers were exchanged and feeding continued for 3 more weeks. In the first 2 weeks, trout predominantly selected the BAL diet to the IMB or PF diet, although some fish failed to switch when the feeders were exchanged to obtain the BAL diet during the latter 3 weeks. In experiment 2, two combinations of four diets, BAL, two IMB and PF, or LP, IMB and two PF, were each offered to five individual trout for 3 weeks. Trout then showed preference for the BAL diet to the IMB and PF diets, and the LP diet to the IMB and PF diets. The preference for the BAL or LP diet gradually increased as the feeding trial progressed. These results suggest that trout preferred a casein-rich balanced amino acid diet regardless of its dietary protein level to a gelatin-rich imbalanced diet or a protein-free diet. To more clearly evaluate the ability of trout to discriminate the amino acid balance of the diets, further studies are necessary using diets with similar texture, tastes or chemical compositions while only differing in single essential amino acids, or those containing the same feeding stimulants.

Reference

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11. Photoperiod manipulation and seawater tolerance in charr

Photoperiod manipulation has been shown to alter the timing of the parr-smolt transformation of many salmonid species within the *Oncorhynchus* and *Salmo* genera but only circumstantial evidence exists for *Salvelinus* species. This study therefore investigated the effects of photoperiod manipulation on the development of seawater tolerance in anadromous Arctic charr. Three groups of fish, previously reared under natural photoperiod and ambient water temperature conditions, were subjected to a constant short daylength, 4L:20D, from 21 December to 30 January, followed by exposure to either 4L:20D, continuous light (24L:OD) or simulated natural photoperiod (nLD). Temperature of the fresh water was held constant at 4°C until mid-May, after which it increased gradually to reach 8.5°C at the termination of the experiment on 2 July. All groups displayed improved seawater tolerance during the course of the study, assessed as changes in plasma chloride and osmolality concentrations following 72-h exposure to seawater (33-34‰). The tolerance to seawater was positively related to fork length within some sampling dates in all groups. Exposure to 24L:OD advanced the development of seawater tolerance by approximately 6 weeks, compared to the nLD group. Both groups displayed increases in gill Na/K-ATPase activity that coincided with the period of improved seawater tolerance. Seawater tolerance of the 4L:20D group was delayed by 6 weeks in comparison with that of the nLD group, but without any concomitant increase in gill Na/K-ATPase activity. The results corroborate previous findings, and suggest that the seasonal changes in seawater tolerance of Arctic charr are controlled by an endogenous, circannual timing mechanism that is entrainable by artificially extended daylengths in spring. The data further suggest that development of seawater tolerance in Arctic charr may occur independently of changes in gill Na/K –ATPase activity.

Reference

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12. Growth, survival and maturation of triploid charr

The production of triploid rainbow trout for the fresh and smoked market reached 10,000 tonnes in France in 1999. Over the past decade a similar interest has been shown for producing sterile triploid Arctic charr in attempts to enhance both quality traits and rearing characteristics relative to diploids, particularly during the period of first sexual maturation. This study assessed the efficiency of hydrostatic pressure shock in inducing triploidy in charr and compared growth rates with diploid controls from the onset of first feeding to the end of the third year of life. Mortality and sterility rates were also determined during the first reproductive period. Pressure shocks of 65 Mpa (650 bar) to induce triploidy were applied to eggs 30, 40 or 50 mins after fertilization for a duration of 5 mins. Triploid yield (percentage of relative survival to controls x percent triploidy) varied from 55 to 100% and was generally in excess of 80%. Despite increased mortality and decreased growth of diploid fish during the spawning period, growth and survival did not differ between diploid and triploid charr up to and during their third year of life. In triploids, 51% of males developed testes but no milt was produced while 13% of females developed ovaries. Fecundity of triploid females was low and fertilised eggs from these fish did not hatch. It was concluded that triploidy did not confer any advantage in terms of growth and survival to the cultivation of Arctic charr.

Reference

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