

Aquaculture

Web Resources

Alestrom P, De la Fuente J (1999) **Genetically modified fish in aquaculture: Technical, environmental and management considerations.** *Biotechnologia Aplicada (Cuba)*. 16 (2):127-130 ISSN: 0864-4551

Descriptors: aquaculture, genetic engineering, health hazard, animal welfare, ethics, environmental impact assessment, research, international cooperation, nonhuman, review

Anonymous (1991) **The role of the veterinarian in fish farming and aquaculture.** *Veterinary Record (England)*. 129(6):124-125.

NAL Call No. 41.8 V641

Descriptors: fisherie, standards, fishes, veterinary medicine, animal welfare, consumer product safety, fish products

Baeverfjord G, Aasgaard T, Lein I, Rye M (1999) *Egg Incubation Temperature is a Critical Factor for Normal Embryonic Development in Atlantic Salmon. International Council for the Exploration of the Sea. Copenhagen (Denmark) Theme Sess. Health and Welfare of Cultivated Aquatic Animals. Council Meeting of the International Council for the Exploration of the Sea, Stockholm (Sweden), 27 Sep-6 Oct 1999. 5 pp.* Compact Disc
 Farmed fish is marketed as high quality products and as healthy foods. Producers are faced with increasing requirements for documentation on sound farming practices, i.e. contents of fish feeds, drug use etc. The average consumer may perhaps be satisfied to know that the fish itself is healthy and normal at the time of slaughter. Deformities in farmed fish clearly represent a problem in this context. If fish with deformities reach the market, consumers may react adversely. A strategy in which deformed fish is produced and subsequently rejected before marketing is hazardous as well as expensive, and can hardly be sustained for a prolonged period of time. And, although individuals displaying deformities may be regarded as a normal feature of any biological population, sudden increases in number of deformed specimen clearly indicates suboptimal conditions. Therefore, substantial efforts were made by the Norwegian industry, as problems with deformed fish came to attention some years ago. During a period of 4-5 years in the mid-nineties, a variety of malformations were observed in farmed Atlantic salmon (*Salmo salar*) in Norway. The observations caused great concern, both as a cause of considerable economical loss to the fish farmers and as an issue of ethical concern. In a project which was initiated by Norwegian Research Council and supported by industry partners, possible causes for malformations were screened.

Descriptors: embryonic development, temperature effects, fish culture, abnormalities,

Salmo salar

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Baeverfjord G (1998) *Ethics and Animal Welfare in Intensive Aquaculture Production*. Copenhagen Denmark ICES. 3 pp.

Descriptors: aquaculture development

Begout ML, Lagardere JP (1999) *Effects of Stocking Densities on Swimming Characteristics of Rainbow Trout: Applying Acoustic Telemetry to the Culture Environment*. International Council for the Exploration of the Sea Copenhagen (Denmark) Theme Sess. Health and Welfare of Cultivated Aquatic Animals. Council Meeting of the International Council for the Exploration of the Sea, Stockholm (Sweden), 27 Sep-6 Oct 1999. 1 pp.

Compact Disc

The authors designed an experiment in order to evaluate the effects of stocking densities on behavioural plasticity considered as potential welfare indicator. The authors measured swimming activity of rainbow trout (*Oncorhynchus mykiss*) cultivated at three stocking densities : 25, 75 and 125 kg/m³. Using acoustic telemetry in tanks, the authors measured swimming activity during 48 h for three fish reared at each density. Water renewal rate was proportionate to fish density to ensure equal water quality and current speed was also similarly regulated. Fish were fed at 1 % ratio through automatic feeders. Strong differences in swimming activity appeared for activity patterns and amplitude. Fish reared at 25 kg/ m³ showed identical patterns and were day active with a maximum level of 117 m/h. One fish reared at medium density displayed a similar pattern to the 25 kg/m³ fish, whereas the other two showed high pattern variability and high swimming activity, up to 221 m/h. At the highest density, the three fish showed similar even patterns with a maximum swimming amplitude of 180 m/h. Other swimming Descriptors such as space use, swimming complexity and instantaneous swimming speeds also differed in each density. From this first experiment, we can infer that behavioural plasticity exists at medium density, whereas swimming activity is constrained at the highest density. (DBO).

Descriptors: Stocking density, *Oncorhynchus mykiss*, behaviour

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Bell A, Bron J, Turnbull JF, Adams CE, Huntingford FA (2002) **Factors influencing the welfare of farmed Atlantic salmon (*Salmo salar*) in commercial marine cages.**

Research in Veterinary Science 72(Supplement A):7-8

NAL Call No. 41.8 R312

Descriptors: aquaculture, behavior, philosophy and ethics, *Salmo salar*, Atlantic salmon, animal welfare, behavior, commercial fish farm, marine cage, space utilization, stocking density

Bell JG, McGhee F, Campbell PJ, Sargent JR (2003) **Rapeseed oil as an alternative to marine fish oil in diets of post-smolt Atlantic salmon (*Salmo salar*): changes in flesh**

fatty acid composition and effectiveness of subsequent fish oil “wash out”.*Aquaculture* –Amsterdam. 218(1-4):515-528

NAL Call No. SH1 A6

Descriptors: nutrition, fish oil alternative, fish physiology, *Salmo salar*, Atlantic salmon

Bernoth EM (1991) **Intensivhaltung von Susswasserfischen. [Intensive culture of fresh water fish.]** *Deutsche Tierärztliche Wochenschrift* (Germany). 98(8):312-316. (In German with English summary)

NAL Call No. 41.8 D482

Recently, eel recirculation systems have provoked increasing attention in intensive fish culture, especially concerning animal welfare. “Aquaculture”, “Intensive Culture”, and “Recirculation Systems” are often confused with each other. This study, first of all, differentiates among these terms. The economic relevance of aquaculture in the Federal Republic of Germany is demonstrated by figures. A tendency towards intensive methods can only be seen in trout and eel culture. The problems of recirculation systems are explained comprehensively. Particular emphasis is laid on the conflict between theoretical suitability of intensive fish production and the absence of commercially working systems. At present, intensive fish culture does not pose a serious animal welfare problem in Germany. However, it is necessary to define the biological requirements of fish concerning their optimal accommodation in aquaculture facilities. According to the Law for the Protection of Animals, these requirements have to be laid down in an ordinance. Only then control is possible as to whether aquaculture systems fulfill fish welfare demands.

Descriptors: animal husbandry, methods, animal welfare, legislation and jurisprudence, fisheries, fishes, growth and development, Germany

Brandt TM, Graves KG, Berkhouse CS, Simon TP, Whiteside BG (1993) **Laboratory spawning and rearing of the endangered fountain darter.** *Progressive Fish Culturist*. 55 (3):149-156

NAL Call No. 157.5 P94

Survival of the fountain darter (*Etheostoma fonticola*), a U.S. federally listed endangered species, may depend on captive propagation. Studies were conducted to determine the effect of temperature on spawning and to develop methods for culture. The fountain darter spawned and produced viable offspring in aquaria at 27, 24, 21, 18, 15, 12, 9, and 6°C. The fish also spawned at 3 and 30°C but did not produce viable eggs. Daily egg production of individual fish held at 27, 21, 15, and 9°C was variable. The mean critical thermal maximum for the fountain darter was 34.8°C. Early life stages, 4-14 mm long, were offered a variety of live protozoans, rotifers, and microcrustaceans. Food selection varied with fish size and food size. Fountain darters reached sexual maturity in about 180 d when maintained at 21°C. Three-year-old darters produced viable offspring, and several lived longer than 4 years. Tricaine methanesulfonate was an effective anesthetic at 60 mg/L but was fatal to subadults at 100 mg/L.

Descriptors: rare species, fish culture, *Etheostoma fonticola*, water temperature, spawning, food organisms, USA, Texas, San Marcos R., laboratory culture, aquaculture
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Broom DM (1998) **Fish welfare and the public perception of farmed fish.** (Eds:) Nash CE, Julien V. *Report Aquavision ' 98 The second Nutreco Aquaculture Business Conference Stavanger Forum, Norway, 13 15 May 1998 Addressing the challenges to maintain a sustainable 10 20% annual growth of the aquaculture industry.* Stavanger Norway Nutreco Aquaculture. pp. 89-91

A discussion is presented on fish welfare and the fish farming industry. Recommendations for improving fish welfare are provided under the following headings: 1) stocking density; 2) feeding methods; 3) stunning; 4) environmental quality enrichment; 5) disease and parasitism; and, 6) handling, grading and transport. It is concluded that the fish farming industry has to have a good image with the public in relation to animal welfare. The industry is vulnerable at the moment, however with some relatively inexpensive changes, the welfare of farmed fish can be good and this fact may be used in marketing.

Descriptors: fish culture, fish diseases, husbandry diseases, environmental diseases, food fish, marketing
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Brown L (1991) **Farmed fish.** Anderson, R.S.; Edney, A.T.B. (eds.) *Practical Animal Handling.* Pergamon Press plc, Oxford, UK. p. 167-169
NAL Call No. SF61 P73 1991

Descriptors: fishes, fish diseases, transport of animals, animal welfare, restraint of animals, fish culture, animal diseases, animal health, animal husbandry, methods, aquaculture, transport

Chatain B, Corrao D (1992) **A sorting method for eliminating fish larvae without functional swimbladders.** *Aquaculture.* 107(1):81-88

NAL Call No. SH1 A6

The authors describe a simple sorting method for separating cultured fish larvae with functional swimbladders from those without based on density differences. The whole population was first anaesthetized with MS 222 and then the fish were separated: fish with a functional swimbladder float and those without sink. The efficiency of the separation method was tested at several anaesthetic doses (0.02 to 0.1 g/l) with sea bass (*Dicentrarchus labrax*) and sea bream (*Sparus auratus*) larvae in the 6-34 mm (total length) range. The minimal sorting size was 15 mm for sea bass with an optimal anaesthetic dose of 0.07 g MS 222/l. There were not enough data to draw conclusions for sea bream. The method was satisfactory when applied in real conditions to a large (90,000) population of sea bass fry with an efficiency ratio of over 80%.

Descriptors: fish larvae, aquaculture techniques, fish culture, *Dicentrarchus labrax*,

Sparus aurata, swim bladder, separation processes
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Cooke M (2001) **Ethical considerations for the production of farmed fish--the retailer's viewpoint.** (Eds:) Kestin SC, Warriss PD. *Farmed Fish Quality*. Osney Mead Oxford OX2 0EL UK. Blackwell Science Ltd. pp. 116-119

NAL Call No. SH151 F37 2001

It may appear anomalous in a chapter about ethics in the context of fish quality, but I am focusing here on trade. Ethics, even in this context, is not just a synonym for animal welfare; it is the cornerstone of exchange. It can be argued that the production and marketing of farmed fish is the subject of four ethical domains: (1) Employment (2) Trading (3) Animal Husbandry, and (4) Environment.

Descriptors: fish culture, seafood, quality control, sociological aspects

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Costello MJ, Grant A, Davies IM, Cecchini S, Papoutsoglou S, Quigley D, Saroglia M. (2001) **The control of chemicals used in aquaculture in Europe.** *Journal of Applied Ichthyology*. 17(4):173-180

NAL Call No. QL614 Z44

A range of chemicals are used in European marine aquaculture and these may be categorized as disinfectants, antifoulants and medicines (includes vaccines). This article provides a review of chemicals used in aquaculture in Europe, their regulatory status, and a checklist of points considered best practice in the use (and avoidance of use) of medicines in marine aquaculture. The release of antifoulants and disinfectants into the marine environment is controlled by local and/or national waste discharge regulations that may in turn be guided by wider environmental quality objectives. The authorization of veterinary medicines, biologicals (vaccines) and pharmaceuticals (chemicals), in Europe is the subject of several EC Directives. Registration dossiers address the issues of product quality, safety and efficacy and include environmental and consumer safety where the product is destined for use in a food-producing animal. Fish farmers, like all livestock producers, must have access to a range of properly authorized medicines to safeguard animal health and welfare. The distribution and supply of medicines must be appropriately controlled and their authorization appropriately includes environmental risk assessment to a common European Union (EU) or international standard. There is progress towards the harmonization of the authorization process within the EU and this will help to ensure the continued availability of medicines for fish. Consumer safety is addressed by the setting of maximum residue limits (MRLs) derived through toxicological risk assessment and by surveillance of food for residues of veterinary medicines. The system for the environmental risk assessment of chemicals used in aquaculture is being developed and is outlined in the present article. It is recommended that the supply and use of fish medicines is uniformly regulated in the EU and supported by appropriate codes of best practice. A number of codes of practice that include reference to the use of medicines have been

produced both at a European level and in member states. It is recommended that all European marine aquaculture producers adopt a code of best practice for the use of medicinal and other chemicals their industry. Medicines are one part of an integrated package in dealing with animal health. This includes environmental conditions, nutrition and hygiene. The best practice guidelines presented here are based on the outcome of three European workshops as part of the EU MARAQUA project that involved industry, government and research scientists. They cover the avoidance and minimizing of the need to use medicines and other chemicals, to recording and monitoring their use and effectiveness (in case of resistance development), exchange of experiences within the industry, and staff training. Recommendations are also included for manufacturers of medicines and other chemicals, and for regulatory authorities. Minimizing the need to use medicines and other chemicals requires attention to a healthy source of fish stock. Staff must be appropriately trained in fish husbandry (to minimize stress), hygiene and disease recognition and treatment, including management of the farm site to keep it disease free. The latter may require single generations of fish per site to allow a fallow period during which a disease or parasite cycle is broken. These recommendations and guidelines are in accordance with the current codes of practice being developed by different sectors of the aquaculture industry in different countries. They do not necessarily involve significantly higher production costs and indeed are more likely to save costs as medicines and disease impacts are very costly to industry.

Descriptors: marine aquaculture, medicine, disinfectants, antifouling substances, waste disposal, legal aspects, *Salmo salar*, *Oncorhynchus mykiss*, *Dicentrarchus labrax*, *Sparus aurata*

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Dobosz S, Kuzminski H (1997) **Full cycle production of the Pomeranian Gulf whitefish.** *Polskie Archiwum Hydrobiologii / Polish Archives of Hydrobiology*. 44(1-2):287-292
NAL Call No. QL614 Z44

In the Inland Fisheries Institute, Salmonid Research Laboratory Rutki the successful attempt of the Pomeranian Gulf whitefish (*Coregonus lavaretus*) full cycle production was performed. In November 1994 the 154 farmed whitefish females were spawned and 16 liters of fertilized eggs obtained. Before spawning fish were immobilized with “Propiscin“ anesthetic, which prevented post spawning broodfish mortality. The hatching was delayed by the incubation in controlled (low) temperature, to obtain alevins during favourable water temperatures. During the first 3 weeks fry were fed with brine shrimps exclusively until obtaining 23.5 mg mean body weight. During the next 4 weeks fish were fed with brine shrimps and trout starter feed alternatively, until fry obtained individual weight 163 mg. During the next 5 weeks fish were fed with trout feed exclusively until the weight 0.95 g. The survival from hatch being 72%. It was proved that the “trout” technology is usefull in whitefish fingerlings and elder fish production.

Descriptors: fish culture, life cycle, induced breeding, mortality, hatching, brood stocks, aquaculture techniques, developmental stages, temperature preferences, *Coregonus lavaretus*, Poland, Baltic whitefish
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Eknath AE, Dey MM, Rye M, Gjerde B, Abella TA, Sevilleja R, Tayamen MM, Reyes RA, Bentsen HB (1998) **Selective breeding of Nile tilapia from Asia.** *Proceedings of the 6th World Congress on Genetics Applied to Livestock Production, Armidale, Australia, January 11-16, 1998. Volume 27: Reproduction; Fish Breeding; Genetics and the Environment; Genetics in Agricultural Systems; Disease Resistance; Animal Welfare; Computing and Information Technology; Tree Breeding.* World Congress on Genetics Applied to Livestock Production. Armidale, Australia. 89-96
NAL Call No. SF105 W67 1998

A programme implemented by International Center for Living Aquatic Resources Management and other research institutes for the genetic improvement of growth rate in Nile tilapia (*Oreochromis niloticus*) is described. It involves (1) the assembling of tilapia germplasm from wild habitats in Africa and from domesticated Asian aquaculture stocks, (2) estimation of genotype x environment interaction in 11 test environments covering diverse Asian farming systems, (3) a complete diallel crossing experiment involving 23 779 individuals in crossbred and pure strain combination to estimate heterosis, and (4) selection for growth rate. Genotype x environment interaction was very low. Heterosis averaged 4.3%, the largest value being 14%. In the base population, made up of individuals from the 25 best-performing purebred and crossbred groups, the estimates of heritability for body weight from the sire and dam components of variance were 0.23 and 0.53 respectively. The genetic gain in growth rate per generation over 5 generations of selection was 12-17%. The production potential of the new strain was compared with existing strains in station and farm experiments in 5 Asian countries. It was found that the cost of production per unit of fish was 20-30% lower for the new strain than for other Nile tilapia strains in current use.
Descriptors: body weight, genetic improvement, tropics, tilapia, *Oreochromis niloticus*, fishes
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Ellis T, North B, Scott AP, Bromage NR, Porter M, Gadd D (2002) **The relationships between stocking density and welfare in farmed rainbow trout.** *Journal of Fish Biology.* 61(3):493-531
NAL Call No. QL614 J68

There is increasing public, governmental and commercial interest in the welfare of intensively farmed fish in UK, and stocking density has been highlighted as an area of particular concern. Here, we draw scientific attention and debate to this emerging research field by reviewing the evidence for effects of density on rainbow trout. Although no explicit

reference to 'welfare' has been made, there are 43 studies which have examined the effects of density on production and physiological parameters of rainbow trout. Increasing stocking density does not appear to cause prolonged crowding stress in rainbow trout. However, commonly reported effects of increasing density are reductions in food conversion efficiency, nutritional condition and growth, and an increase in fin erosion. Such changes are indicative of a reduced welfare status; although, the magnitude of the effects has tended to be dependent upon study-specific conditions. Systematic observations on large scale commercial farms are therefore required, rather than extrapolation of these mainly small-scale experimental findings. There is dispute as to the cause of the observed effects of increasing density, with water quality deterioration and/or an increase in aggressive behaviour being variously proposed. Both causes can theoretically generate the observed effects of increasing density, and the relative contribution of the two causes may depend upon the specific conditions. However, documentation of the relationship between density and the effects of aggressive behaviour at relevant commercial densities is lacking. Consequently only inferential evidence exists that aggressive behaviour generates the observed effects of increasing density, whereas there is direct experimental evidence that water quality degradation is responsible. Nevertheless, there are contradictory recommendations in the literature for key water quality parameters to ensure adequate welfare status. The potential for welfare to be detrimentally affected by non-aggressive behavioural interactions (abrasion, collision, obstruction) and low densities (due to excessive aggressive behaviour and a poor feeding response) have been largely overlooked. Legislation directly limiting stocking density is likely to be unworkable, and a more practical option might be to prescribe acceptable levels of water quality, health, nutritional condition and behavioural indicators.

Descriptors: aggressive behaviour, animal behaviour, animal welfare, fish culture, fish farms, overcrowding, stocking density, stress, water quality, rainbow trout, *Salmo*, aquatic
Copyright © 2003, CAB International.

Etscheidt J, Manz D (1992) **Susswasseraquaristik und tierärztliche Praxis. Teil 2: Untersuchungen zur artgerechten Haltung von Zierfischen. [Fresh water aquaria and veterinary practice. 2. Studies of proper raising of ornamental fish.]** *Tierärztliche Praxis* (Germany). 20(2):221-226. (In German with English summary)

NAL Call No. SF603.V4

The environmental conditions in 103 fresh-water aquaria were examined and the results compared to the standards as described in part 1 of this publication. The aim was to assess whether the care of aquarium fish was adequate in regard to management and the legal requirements of animal welfare. Disclosed faults are discussed and recommendations for their elimination and avoidance are suggested.

Descriptors: animal welfare, fishes, physiology, fresh water, chemistry, algae growth and development, animal fee, legislation and jurisprudence, Germany, temperature, microbiology

Ewbank R, Kim-Madslien F, Hart CB (1999) *Management and Welfare of Farm Animals: UFAW Farm Handbook*. Universities Federation for Animal Welfare UK, 308 pp.

NAL Call No. SF61 M35 1999

At a time when the quality of management of farm livestock is under threat from economic forces, this new edition is as relevant as ever in pointing the way to optimum conditions. There are chapters on the care of dairy cattle, beef cattle (and veal calves), sheep, goats, pigs, rabbits, red deer, laying hens, broiler chickens, turkeys, ducks, quail production, guineafowl and fish farming. Students of agriculture and of veterinary medicine will benefit from it. Previous editions appeared in 1971, 1978 and 1988.

Descriptors: animal husbandry, animal welfare, livestock, animal production, poultry, nutrition, animal breeding, fishes, cattle, sheep, goats, pigs, rabbits, red deer, aquatic animals

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Gregory NG (2000) **Animal welfare in the fish industry.** *Surveillance (Wellington)*. 27 (2):8-10

NAL Call No. SF604.63.N45S87

Descriptors: animal welfare, fisheries, aquaculture, stress, fishing, fish farming, fishes, aquatic animals

Hussain MG (1998) **Manipulation of chromosomes in fish: Review of various techniques and their implications in aquaculture.** *Bangladesh Journal of Fisheries Research*. 2(1):99-108. ISSN: 1026-6690

Human ingenuity has made it possible to advent the chromosome manipulation techniques to produce individuals with differing genomic status in a number of fish using various causal agents such as physical shocks (temperature or hydrostatic pressure), chemical (endomitotics) and anaesthetic treatments either to suppress the second meiotic division shortly after fertilization of eggs or to prevent the first mitotic division shortly prior to mitotic cleavage formation. This results in the induction of polyploidy (triploidy and tetraploidy), gynogenesis (both meiotic and mitotic leading to clonal lines) and androgenesis in fish population. The rationale for the induction of such ploidy in fish has been its potential for generating sterile individuals, rapidly inbred lines and masculinized fish, which could be of benefit to fish farming and aquaculture. In this paper, these are critically reviewed and the implication of recently developed chromosome manipulation techniques to various fin fishes is discussed.

Descriptors: aquaculture techniques, fish culture, biotechnology, reproduction, chromosomes, cell division, fish eggs, polyploids, gynogenesis, androgenesis, clones, hybrid culture

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Hurnik JF, Lehman H (1988) **Ethics and farm animal welfare**. *Journal of Agricultural Ethics*. 1(4):305-318.

NAL Call No. BJ52.5 J68

Descriptors: *Salmo gairdneri*, mucus, toxicity, water, pollution, acids, aluminium, zinc, animal morphology, body fluids, bony, fishes, elements, heavy metals, metallic elements, salmonoidei

Kolle P, Hoffmann R (1997) **Qualzuchten bei Fischen [Excessive breeding in ornamental fish]**. *Deutsche Tierärztliche Wochenschrift*. 104(2):74-75 (In German with English summary)

NAL Call No. 41.8 D482

Descriptors: breeding, fish, ornamental fishes, aquarium fishes, animal welfare, goldfish, *Carassius, poeciliidae*

Lines JA, Frost AR (1999) **Review of opportunities for low stress and selective control of fish**. *Aquacultural Engineering*. 20 (4):211-230.

NAL Call No. SH1.A66

Descriptors: fishes, animal welfare, fish culture, fish farms, equipment, selection, sampling, senses, trauma, diseases, inspection, evaluation, literature reviews

Lefrancois C, Mercier C, Claireaux G (1999) *Effect of Rearing Density on the Routine Metabolic Expenditure of Farmed Rainbow Trout (Oncorhynchus mykiss)*. Copenhagen Denmark ICES. Council Meeting of the International Council for the Exploration of the Sea, Stockholm (Sweden), 27 Sep-6 Oct 1999. 16 pp. Compact Disc.

For an intensive rearing system, increasing the fish stocking density is one way to optimize productivity. However, a too high density can become stressful for the fish and constrain its growth capacity. This negative effect seems to partly mediate through fish behavioral changes (increase of social interactions: aggression, chase, hampering,..) which induce supplementary metabolic expenditure to the detriment of the fish growth. The objectives of this study are (i) to examine the effects of rearing density on the rainbow trout (*Oncorhynchus mykiss*) routine metabolic rate (RMR), (ii) to estimate the species metabolic scope, which represents the energy available to ensure the animal activities (iii) to determine the share of metabolic scope consumed by the density dependent RMR changes. Respirometry experiments were conducted at three densities: 25, 65 and 100 kg/m³ with 11°C-acclimated and starved rainbow trout (261 ± 5 g). The only significant effect of density was shown between 65 and 100 kg /m³ (100.76 ± 1.28 and 104.72 ± 1.29 mgO₂/kg/h, respectively). No significant difference was observed neither between 25 (102.83 ± 1.47 mgO₂/kg/h) and 65, nor between 25 and 100 kg/m³. Furthermore, the metabolic scope of the rainbow trout was estimated to 285 mgO₂/kg/h. When analyzed with regard to fish metabolic capacities, the RMR corresponded to less than 16% of the animal scope, and RMR variations to less than 1.4%. In the range tested, the density does not affect the routine metabolism

of rainbow trout and is not harmful to the realization of the natural fish activities, such as growth. However, if a density of 100 kg /m³ seems to be applied in routine conditions without increasing oxygen demand, similar studies need to be conducted in different experimental stimulation, e.g. during feeding phase.

Descriptors: rearing, stocking density, animal metabolism, biological stress, aggressive behaviour, *Oncorhynchus mykiss*

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Lymbery P (1992) **Welfare of farmed fish.** *Veterinary Record* (England). 131(1):19-20.
NAL Call No. 41.8 V641

Descriptors: animal welfare, fisherie, standard, fishes, Great Britain

Maule AG, Schrock RM, Fitzpatrick MS, Schreck CB (1994) **Immune-endocrine interactions during final maturation and senescence of spring chinook salmon.** *High Performance Fish: Proceedings of an International Fish Physiology Symposium at the University of British Columbia in Vancouver, Canada, July 16-21 1994.* Fish Physiology Association, Vancouver, BC (Canada). pp. 170-171

NAL Call No. QL639.1 I58 1994

Adult Pacific salmon (*Oncorhynchus spp.*) present a unique model for immune-endocrine interactions because the processes of sexual maturation and senescence occur simultaneously. We examined: (1) the ability of peripheral blood leukocytes (PBLs) to generate specific antibody-producing cells (APC) and (2) lysozyme activity in skin, nares, mouth, intestinal mucus, and in serum from the primary and secondary circulation in adult spring chinook salmon (*O. tshawytscha*). We also measured concentrations of steroid hormones in primary and secondary circulation and cortisol receptors in PBLs. Plasma concentrations of the stress hormone cortisol were high (> 200 ng/ml) compared to that of unstressed juvenile salmon (Maule et al. 1989); cortisol decreased (< 175 ng/ml) in fish held under constant environmental conditions. However, these values may not reflect true resting levels because of stress associated with collecting fish and the sublethal doses of anesthetic used (Barton et al., 1986). APCs were low (less than or equal to 250 APC per culture) in fish sampled during their migration, but increased significantly (greater than or equal to 400 APC per culture) when fish were held in constant environmental conditions. While the APC response was not sexually dimorphic, concentrations of several sex steroids were correlated with APC in females but not males. Lysozyme activity was significantly higher in mucus from skin, nares and vent than in serum from primary or secondary circulation.

Descriptors: sexual maturation, biological aging, endocrinology, sex hormones, immunity, spring, *Oncorhynchus tshawytscha*

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McLay HA, Youngson AF, Wright RS, Johnstone R (1992) **Effects of rearing density on sexual maturation and growth in sea-cage reared Atlantic salmon, *Salmo salar* L.** *Aquacult. Fish. Manage.* 23(3):353-365.

Paired subgroups of fish were derived in January from each of two parent sea-cages of

Atlantic salmon, *Salmo salar*. The proportion of fish which later became sexually mature in each parent group, after one winter (as grilse) and under commercial rearing density, was determined. Maturity rates in the subgroups, reared in sea-cages at low density, were significantly greater than in the parent groups. Rearing at reduced density was associated with increased growth in some, but not all, comparisons. Periodic anaesthesia, handling and sampling of blood for steroid hormone determinations did not consistently affect maturation rate or growth among fish in one of each pair of subgroups. Sexual development was assessed by determining levels of the steroid hormones 11-oxotestosterone or 17 beta - oestradiol in samples of blood serum taken monthly from individually marked fish in one of each pair of subgroups.

Descriptors: growth, population density, fish culture, sex hormones, *Salmo salar*, density dependence, sexual maturity

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Midtlyng PJ, Bjerkas E, Waagbo R, Rodger H, Wall T, Palmer R, Breipohl W (1998) **Cataracts in farmed fish---A multidisciplinary initiative for scientific programme.** *Third European Marine Science and Technology Conference MAST Conference, Lisbon, 23 27 May 1998: Project Synopses Vol 6: Fisheries and Aquaculture FAIR: 1994 98, Selected Projects from the Research Programme for Agriculture and Fisheries including Agro Industry, Food Technology, Forestry, Aquaculture and Rural Development FAIR. Luxembourg Luxembourg European Commission DG 12 Science, Research and Development. 6:341-343*

Cataracts (reversible or irreversible lens opacities) is a production disorder of several species of fish. The aim of this project is to disseminate knowledge on occurrence and causation of cataracts in farmed fish, and to initiate further research to prevent and control the disease. To achieve this goal, we propose to create a multidisciplinary network of European scientists and aquaculture industrialists to overcome present restraints in research. The project will thus contribute to secure the health and well being of farmed fish, and improve the cost effectiveness of European aquaculture. The competitive advantage of European suppliers of materials or services to the international aquaculture market will be increased. Successful control of cataracts is considered even more important in order not to compromise consumer perception of the aquaculture industry as such, particular regarding its ethical standards of production and the quality of its products. These issues are of major importance for the industry's further competitiveness in the international food market. Bringing the aquaculture industry, fish pathologies and nutritionists together with multidisciplinary working ophthalmologists, a new and unique scientific collaboration for the benefit of future aquaculture production, fish welfare and fish health research will be created, in itself a most valuable goal. These main objectives have been detailed as follows: The project will disseminate scientific knowledge and state of the art in cataract research, and discuss current and planned work conducted in this field. The project will facilitate exchange of study specimen and transfer of research methodology between laboratories. The project will initiate epidemiological studies and thus provide new scientific data on the occurrence and economy of the disease. New

research on the physiology of the fish eye and the pathogenesis of lens cataracts will be stimulated. Financial support for explanatory studies on the cataract problem will be sought.

Descriptors: animal physiology, aquaculture, fish culture, pathology, eyes

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Olesen I, Bentsen HB (1999) **Breeding programs for sustainable fish production.**

Nordisk Jordbrugsforskning. 81(3):258-266

NAL Call No. 11 N752

The definition of breeding goals for sustainable fish production are considered, with emphasis on ethical as well as economic values. Compared with livestock, fish farming is at an early stage of domestication and breeding, although rapid selection responses for growth rate have already been established in several species. More basic knowledge is needed so that welfare standards and normal behaviour of fish can be maintained during selection programmes. The genetic requirements for a long-term selection programme are discussed including continuous (re) introduction of genetic variability from outside the breeding nucleus without adverse performance consequences.

Descriptors: fish production, aquaculture, breeding programmes, domestication, ethics, fitness, genetic drift, genetic variation, growth rate, inbreeding, natural selection, selection, selection responses, adverse effects, sustainability

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Pante MJR, Gjerde B, McMillan I (1998) **Inbreeding levels and inbreeding depression in a farmed population of rainbow trout (*Oncorhynchus mykiss*).** *Proceedings of the 6th World Congress on Genetics Applied to Livestock Production, Armidale, Australia, January 11-16, 1998. Volume 27: Reproduction; Fish Breeding; Genetics and the Environment; Genetics in Agricultural Systems; Disease Resistance; Animal Welfare; Computing and Information Technology; Tree Breeding.* World Congress on Genetics Applied to Livestock Production. Armidale, Australia. 119-122

Proceedings of the 6th World Congress on Genetics Applied to Livestock Production, Armidale, Australia, January 11-16, 1998. Volume 27: Reproduction; Fish Breeding; Genetics and the Environment; Genetics in Agricultural Systems; Disease Resistance; Animal Welfare; Computing and Information Technology; Tree Breeding. World Congress on Genetics Applied to Livestock Production. Armidale, Australia. 119-122

NAL Call No. SF105 W67 1998

Data on a population of rainbow trout that had been selected (mainly for growth rate) for 6 generations were analysed. The level of inbreeding in generations 2-6 averaged 2.9, 2.8, 8.5, 8.0 and 6.6% respectively; corresponding values of the percentage of individuals with inbreeding greater than zero were 59.3, 49.8, 87.1, 82.8 and 81.4. The rate of increase in inbreeding over generations was non-linear, the average being 1.3% per generation. Body weight at harvest was depressed by 0.2% per 1% increase in inbreeding.

Descriptors: inbreeding depression, inbreeding, body weight, rainbow trout, fishes, *Salmo*

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Peters G (1990) **Tierschutzprobleme in der Massenhaelterung von Nutzfischen. [Problems concerning animal protection laws in connection with mass culture of fishes.]** *Deutsche Tieraerztliche Wochenschrift.* 97(3):157-160.

NAL Call No. 41.8 D482

Descriptors: fishes, animal husbandry methods, aquaria, animal welfare, large scale husbandry, animal collections, animal health, animal husbandry methods, animals, aquatic animals, aquatic organisms, collections, methods, vertebrates, zootechny

Pironet FN, Jones JB (2000) **Treatments for ectoparasites and diseases in captive Western Australian dhufish.** *Aquaculture International*. 8(4):349-361

NAL Call No. SH1.A627

The Western Australian dhufish (*Glaucosoma hebraicum*), an open-water marine finfish, has been identified as a potential species for aquaculture and a 4 y research project has concentrated on broodstock collection and maintenance, spawning and larval rearing. This paper describes treatments which were developed for the ectoparasites and diseases of broodstock fish. These included bacterial and fungal infections, *Cryptocaryon irritans*, *Haliotrema* sp., an unidentified axinid monogenean, the isopod *Aega cyclops* and copepod *Caligus* sp. Treatments based on betadine, formalin, freshwater, malachite green, oxytetracycline (terramycin), 2-phenoxyethanol, potassium permanganate and trichlorphon (neguvon) were all tried. The most effective treatments against parasites were a freshwater bath or a combined freshwater bath and anaesthesia with 2-phenoxyethanol. Monogeneans on the gills were difficult to control and exophthalmia was an unresolved problem.

Descriptors: ectoparasites, parasite control, therapy, fish diseases, pathogenic bacteria, aquaculture development, disease control, fungal diseases, *Haliotrema*, *Cryptocaryon irritans*, *Caligus*, *Aega*, *Glaucosoma hebraicum*, ISW, Australia, Western Australia ASFA; Copyright © 2003, FAO

Poppe TT, Barnes AC, Midtlyng PJ (2002) **Welfare and ethics in fish farming.** *Bulletin of the European Association of Fish Pathologists*. 22 (2):148-151 ISSN: 0108-0288

Descriptors: animal health, animal welfare, fish farming, Atlantic salmon, fishes, *Salmo*, aquatic animals

Roberts R (1979) **The fish farming industry.** *The Welfare of the Food Animals. Proceedings of a UFAW symposium held on 28th-29th September 1978.* Universities Federation for Animal Welfare, 8 Hamilton Close. South Mimms, Hertfordshire, UK. p.64-66

NAL Call No. HV4704 U5

Descriptors: slaughter, carbon dioxide, animal welfare, fish farming, fishes, trout, Salmonidae, Salmoniformes

Schnick RA (1996) **Cooperative Fish Therapeutic Funding Initiative: States in partnership with federal agencies to ensure the future of public fish culture.**

Transactions of the North American Wildlife and Natural Resources Conference. pp. 553-557

NAL Call No. 412.9 N814

The impetus for the Cooperative Fish Therapeutic Funding Initiative was and is the lack of properly approved drugs to reduce disease-related mortality and improve production efficiency and product quality on public aquaculture facilities. This crisis requires more cost-effective methods to gain approval of drugs for use in public aquaculture. Public concerns about human food safety, human health and environmental impacts have resulted in increasingly strict interpretation and enforcement of regulations by the U.S. Food and Drug Administration (FDA). Such actions have drastically curtailed the availability and use of drugs essential to maintain fish health in hatcheries. Drug and chemical manufacturers are reluctant to undertake any significant efforts to gain approval of aquaculture drugs because the market potential for these products is below the potential sales target for research investment (estimated to be \$3.5 million for one fish species and one disease). The approval of a drug by FDA can only be obtained with the development of required safety and efficacy data that leads to a new animal drug application (NADA) that is submitted to FDA for review and approval. The process to generate all the data and have the NADA approved by FDA may take 5 to 10 years. Only three therapeutants and one anesthetic are currently approved and available to hatchery managers. It became apparent to a number of individuals, agencies and organizations that a massive, coordinated and cooperative effort was needed to resolve this crisis. This is the story of how various groups have joined together to meet this awesome responsibility.

Descriptors: drugs, disease control, fish culture, government policy, public health, product development, USA

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Schnick RA, Gingerich WH, Koltjes KH (1996) **Federal-state aquaculture drug registration partnership: A success story in the making.** *Fisheries*. 21(5):4

NAL Call No. SH1.F54

During the past 20 years, aquaculture has grown both as a vital tool for fisheries management and as a viable industry. But now a crisis has arisen from the Food and Drug Administration's (FDA) increased regulation of drug use in aquaculture in response to public concerns about human food safety, human health, and environmental effects. Lack of approved drugs and chemicals has dramatically reduced the effectiveness and increased the cost of fish production for natural resource management agencies. To make badly needed therapeutants available, the FDA is requiring an array of specialized laboratory research studies and clinical field trials. Pharmaceutical manufacturers are reluctant to undertake any major efforts to gain approval of aquaculture drugs because each (i.e., use on one species for one purpose) is estimated to cost a minimum of \$3.5 million. Hence, the expenditure is not warranted by the apparent market potential. Only three therapeutants and one anesthetic are currently approved and available to hatchery managers.

Descriptors: aquaculture products, aquatic drugs, pharmacology, legislation, USA, disease

control, aquaculture, pharmaceuticals
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Schwedler TE, Johnson SK (2000) **Animal welfare issues. Responsible care and health maintenance of fish in commercial aquaculture.** *Animal Welfare Information Center Bulletin.* 10(3/4):3-9

NAL Call No. aHV4701 A952

Descriptors: aquaculture, animal welfare, angling, fish farming, stress, water quality, stocking density, fish diseases, disease prevention, fishes

Sievers G, Lobos C, Inostroza R, Ernst S (1996) **The effect of the isopod parasite *Ceratothoa gaudichaudii* on the body weight of farmed *Salmo salar* in southern Chile.**

Aquaculture. 143 (1):1-6

NAL Call No. SH1 A6

A study of the isopod *Ceratothoa gaudichaudii*, a parasite on farmed Atlantic salmon (*Salmo salar*) was carried out on Guar Island, Chile, between May 1993 and August 1994. A total of 671 salmon, with an initial body weight of 0.9 kg to 1.1 kg, was selected; one third were naturally infected with one or two growing parasites. The fish were kept in a separate cage and were examined individually, under anaesthesia, five times during the study. On each occasion, the weight and number of the parasites on each fish was recorded. There was an increase in the prevalence of the parasitosis from 33.4% to 98.2%; concurrently, the total number of parasites on salmon rose from 309 to 3987 with an increase of infestation intensity from 1.4 to 6.1 parasites per fish. No adult females with eggs or larvae were found. At the end of the study, salmon with less than three parasites weighed 4428 ± 949 g; those with three to eight parasites weighed 4151 ± 983 g, and those with more than eight parasites weighed 3763 ± 1056 g. A significant difference in weight ($P < 0.05$) among the three groups was detected.

Descriptors: *Ceratothoa gaudichaudii*, ectoparasites, body weight, *Salmo salar*, PSW, Chile, Los Lagos, Guar Island, fish culture, isopoda, Chile, fish diseases

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Stankovic B (1998) **Higijensko-sanitarni i zootehnicki standardi u uzgoju morske ribe. [Hygienic and zootechnical standards in marine fish farming.]** Ed: Vinkovic B. *The Proceedings of the 3rd Scientific Symposium on DDD with International Participation. Let Healthy Stay Healthy, Zadar, Croatia, 7-9 May, 1998.*

Hrvatska veterinarska komora, Zagreb, Croatia. 293-296 (In Hungarian with English summary) ISBN: 953-96576-4-4

Descriptors: disinfection, hygiene, marine fishes, animal welfare, Aquaculture

Stobo WT (1972) **Effects of formalin on the length and weight of yellow perch.**

Transactions of the American Fisheries Society. 101(2):362-364

NAL Call No. 414.9 AM3

Data for fish growth studied often derive from formalin preserved specimens, but little information is available on the effect of the preservation on spiny-rayed fishes. The effect of 10% formalin on length and weight of yellow perch (*Perca flavescens*) was checked during an 18.5 months period. 55 perch were left in anaesthetic solution (0.8% ethylether) until death. Length and weight were recorded prior to death, after 1 hour, then after 1 hour in formalin. Observations were repeated on a geometric time scale for 1 week, weekly for 1 month, then monthly for 7 months and finally 18.5 months after killing. Tabled results show immediate shrinkage in small fish, largely complete in 24 hour but an initial increase in large fish with subsequent shrinkage complete in 5 days. No length corrections are thought necessary for preserved perch. In all perch weight showed an initial rapid increase, which slowed for a short period, then a protracted period of increase followed by a period of decrease (135 to 557 days).

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Descriptors: formalin, yellow perch, spiny-rayed fishes, anesthetic

Waldbieser GC (1996) **Polymerase chain reaction amplification of genetic loci from diseased channel catfish found dead in ponds.** *Journal of Aquatic Animal Health.* 8 (2):155-158

NAL Call No. SH171.J68

As part of a selective breeding program for farm-raised channel catfish *Ictalurus punctatus*, we screened diseased fish to identify genetic markers linked to disease resistance or susceptibility. Because many diseased fish in ponds are not detected until after death, we investigated the utility of DNA isolated from diseased channel catfish found dead in ponds. Channel catfish (4-25 g) diagnosed with enteric septicemia of catfish or saprolegniasis were sampled 24-48 h postmortem from infected ponds. Control fish were killed by anesthetic overdose and sampled immediately. Total DNA isolated from liver, muscle (with skin), and caudal fin was quantified and analyzed for degradation. Yield of purified DNA, measured as micrograms of DNA per milligram of tissue, was significantly ($P < 0.05$) lower in diseased fish than in controls. Two sets of DNA primers were used to amplify a portion of the channel catfish growth hormone gene and the mitochondrial D-loop region with the polymerase chain reaction. Degradation of DNA in liver and the caudal fin of some diseased fish inhibited successful amplification. Amplification of fragments up to 1,000 base pairs long from genomic DNA of post-mortem channel catfish will be useful for identifying molecular genetic markers linked to disease susceptibility.

Descriptors: selective breeding, disease resistance, *Ictalurus punctatus*, DNA, polymerase chain reaction, genetic markers, septicemia, saprolegniasis, growth hormone, USA, Mississippi

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Wall T, Southgate PJ (1992) **Welfare of farmed fish.** *Veterinary Record* (England). 130 (24):543

NAL Call No. 41.8 V641

Descriptors: animal welfare, fishes, animals, domestic, veterinary medicine, aquaculture

Wedekind C, Muller R, Steffen A, Egger R (2001) **A low-cost method of rearing multiple batches of fish.** *Aquaculture.* 192(1):31-37

NAL Call No. SH1 A6

Experimental studies based on inferential statistics typically require the rearing of many batches of eggs or fish separately. If this is done with conventional fish rearing methods, the need for laboratory space and equipment are normally very high. This may prevent many researchers from experimentally approaching problems in fish genetics or ecology, especially if treatment differences are expected to be small. We have developed and successfully tested a new procedure with *Coregonus sp.* fry. Eggs were hatched in Petri dishes kept at 6°C. Yolk-sac fry were reared in a hanging bag system at 15°C with continuous water exchange. We estimate that our new fry-rearing method reduces space needs, infrastructure and material costs by a factor of 10 or more, while being comparable to previously described methods with respect to animal welfare requirements and the experimenter's working time.

Descriptors: aquaculture techniques, hatching, rearing, survival, experimental research, economics, costs, test organisms, fry

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Web Resources:

Aspects of Animal Welfare and Aquaculture - A Compendium of Selected Literature by Richard D. Moccia and Kristopher P. Chandroo; Aquaculture Centre, University of Guelph, Guelph, Ontario, Canada

<http://www.aps.uoguelph.ca/~aquacentre/aec/publications/welfare-bib.html>

Code of Environmental Management Practices: For Well Managed Salmonid Farms
Fundacion Chile

http://www.fisheries.org/CBPA_2003_english.pdf

CVM Guide 1240.4200

Low Regulatory Priority Aquaculture Drugs

<http://www.fda.gov/cvm/index/aquaculture/LRPDrugs.pdf>

CVM Guide 1240.4260

Classification of Aquaculture Species as Food or Nonfood

http://www.fda.gov/cvm/index/policy_proced/4260.pdf

Drugs Approved for Use in Aquaculture

<http://www.fda.gov/cvm/index/aquaculture/appendixa6.htm>

Fish Farming and Organic Standards

Briefing Paper

Soil Association

http://www.soilassociation.org/web/sa/saweb.nsf/librarytitles/Briefing_Sheets18102002.html

Fiskeriforkning Info No. 6 May 1999

Norwegian Institute of Fisheries and Aquaculture, Ltd. (NIFA)

<http://www.fiskforsk.norut.no/0699e.pdf>

Government Response to the Farm Animal Welfare Council's Report on the Welfare of Farmed Fish

DEFRA, United Kingdom

<http://www.defra.gov.uk/animalh/welfare/farmed/othersps/fish/fawc-fish/fawcftoc.htm>

In Too Deep: The Welfare of Intensively Farmed Fish

A Report for Compassion in World Farming Trust

Philip Lymberly, 2001

http://www.eurocbc.org/itd10pg_In_too_deep_CIWFpdf.pdf

Pisces: Health and Welfare of Fish

http://www.piscestt.com/pisces/hottopics/healthandwf0_en.asp

Report on the Welfare of Farmed Fish

Farm Animal Welfare Council

<http://www.fawc.org.uk/reports/fish/fishrtoc.htm>

Science Directorate Report of the Workshop on Farmed Fish Welfare

UK Department of the Environment, Food, and Rural Affairs

<http://www.defra.gov.uk/science/Publications/Report%20of%20the%20Workshop%20on%20Farmed%20Fish%20Welfare.pdf>

... a variety of morphological, physiological and histopathological indicators of fish welfare status ... 3. Review of scientific literature on effects on rainbow trout ...

UC Davis –Gateway to Information on Optimal Care and Welfare of Fish

<http://www.vetmed.ucdavis.edu/CCAB/fish.htm>

Welfare of Farmed Fish

Pain and Fish Welfare

<http://www.vet.ed.ac.uk/animalwelfare/Fish%20pain/welfare.htm#FARMED>

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