A comprehensive approach to assess feathermeal as an alternative protein source in aquafeed

The effect of partially replacing fishmeal in aquafeed with feathermeal (FTH) at three levels (0%: FTH0, 8%: FTH8, 24%: FTH24) and two extrusion temperatures (100 and 130 °C) were evaluated in rainbow trout (Oncorhynchus mykiss) with respect to growth performance, metabolism response, and oxidative status of the feed proteins. Multivariate data analyses revealed that FTH24 correlated positively with high levels of: oxidation products, amino acids (AA) racemization, glucogenic AAs level in liver, feed intake (FI), specific growth rate (SGR), and feed conversion ratio (FCR); and low AAs digestibility. Both FI and SGR were significantly increased when 8 and 24% feathermeal was included in the feed extruded at 100 °C, while there was a negative effect on FCR in fish fed FTH24. In conclusion, higher oxidation levels in FTH24 may give rise to metabolic alterations while lower levels of FTH may be considered as fishmeal substitute in aquafeed for rainbow trout.
Carryover of CH$_3$Hg from feed to sea bass and salmon

Contamination of food generally has a negative impact on the quality and may imply a risk to human health. Mercury (Hg) is one of the most hazardous compounds in our environment and is released from the earth’s crust by both natural and anthropogenic processes. The mercury species ‘methylmercury’ is highly toxic, because affects the function of enzymes, easily crosses the blood-brain and the placenta barriers and is toxic to the nervous system (especially the developing brain). It bioaccumulates and biomagnifies through the aquatic food chain. Methylmercury is the most common mercury species in fish and humans are also mainly exposed to methylmercury from consumption of fish and other seafood. The aims of the present controlled fish feeding trials were to study the carryover from feed to fish fillets (at low spike levels (1x background level of methylmercury) and to determine toxicokinetic parameters. The study included Atlantic salmon (Salmo salar), which is one of the main farmed seafood product consumed in Europe and with production in Northern Europe as well as European seabass (Dicentrarchus labrax) produced in Southern Europe, where it is a highly consumed seafood. The weight gain of the fish, their feed intake, feed and fish fillet contaminant level were determined to model the uptake and elimination of methylmercury. The toxicokinetics for feed with low levels of methylmercury (41-75 ng/g) showed high assimilation and low elimination. Acknowledgments The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under the ECsafeSEAFOOD project (grant agreement n° 311820).
Carryover of methylmercury from feed to seabass and salmon

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Authors: Rasmussen, R. R. (Intern), Håland, W. (Ekstern), Larsen, B. K. (Intern), Kotterman, M. (Ekstern), Sloth, J. J. (Intern), Marques, A. T. (Ekstern), Granby, K. (Intern)
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Stress and recovery from trawl capture of Norway lobster (Nephrops norvegicus) and potential for live storage

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Authors: Skov, P. V. (Intern), Methling, C. (Intern), Larsen, B. K. (Intern), Unmack, C. P. (Ekstern), Karlsen, J. D. (Intern), Behrens, J. (Intern)
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The composition of readily available carbon sources produced by fermentation of fish faeces is affected by dietary protein:energy ratios

Fish solid waste (faeces) produced in recirculated aquaculture systems (RAS) might be used for on-farm, single-sludge denitrification if transformed into soluble organic carbon substances. The current study investigated the effect of feeding diets with increasing protein to energy ratios (P:E) 15, 17, 19, 21 and 23 g/MJ) to rainbow trout (Oncorhynchus mykiss) on the production of volatile fatty acids (VFAs) and ethanol during 7 days fermentation of the produced fish faeces. The total yields of VFAs and ethanol obtained (expressed as chemical oxygen demand (COD)) ranged between 0.21 ± 0.24 gCOD/gTCOD, showing no differences between treatments. However, the type and quantities of individual VFAs and ethanol changed according to the dietary treatment. Lower P:E ratio diets resulted in higher production of butyric acid and ethanol, whereas higher P:E ratio diets resulted in an increased production of acetate and valeric acid. Changing the diet composition thus affects the composition of readily available carbon that can be derived from the faeces. This can be applied to enhance on-farm single sludge denitrification and reduce the need for adding external carbon sources such as e.g. methanol.
Aquatic Science, Ethanol, Fermentation, Protein:energy, Single-sludge denitrification, VFAs, Butyric acid, Chemical oxygen demand, Denitrification, Fatty acids, Fish, Organic carbon, Proteins, Aquaculture systems, Carbon source, Dietary proteins, Dietary treatments, Rainbow trouts (Oncorhynchus mykiss), Valeric acids, Volatile fatty acids (VFAs), Volatile
The influence of microplastic inclusion in feed on carryover of environmental pollutants from feed to seabass and salmon

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Authors: Granby, K. (Intern), Rasmussen, R. R. (Intern), Kotterman, M. (Ekstern), Sloth, J. J. (Intern), Cederberg, T. L. (Intern), Marques, A. T. (Ekstern), Koelmans, A. (Ekstern), Larsen, B. K. (Intern)
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Toxicity of emerging chemical contaminants evaluated in vivo with classic and alternative approaches using the zebrafish animal model

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Organisations: National Institute of Aquatic Resources, Section for Aquaculture, National Food Institute, Research Group for Analytical Food Chemistry
Authors: Rainieri, S. (Ekstern), Conlledo, N. (Ekstern), Larsen, B. K. (Intern), Granby, K. (Intern), Barranco, A. (Ekstern)
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Effects of dietary microplastic exposure on the organ toxicity of a mixture of chemical contaminants in zebrafish

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Authors: Rainieri, S. (Ekstern), Conlledo, N. (Ekstern), Larsen, B. K. (Intern), Granby, K. (Intern), Barranco, A. (Ekstern)
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Effects of dietary microplastic exposure on the organ toxicity of a mixture of chemical contaminants in zebrafish (Danio rerio)

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Increasing levels of dietary crystalline methionine affect plasma methionine profiles, ammonia excretion, and the expression of genes related to the hepatic intermediary metabolism in rainbow trout (Oncorhynchus mykiss)

Strictly carnivorous fish with high requirements for dietary protein, such as rainbow trout (Oncorhynchus mykiss) are interesting models for studying the role of amino acids as key regulators of intermediary metabolism. Methionine is an essential amino acid for rainbow trout, and works as a signalling factor in different metabolic pathways. The study investigated the effect of increasing dietary methionine intake on the intermediary metabolism in the liver of juvenile rainbow trout. For this purpose, five diets were formulated with increasing methionine levels from 0.60 to 1.29% dry matter. The diets were fed in excess for six weeks before three sampling campaigns carried out successively to elucidate (i) the hepatic expression of selected genes involved in lipid, glucose and amino acid metabolism; (ii) the postprandial ammonia excretion; and (iii) the postprandial plasma methionine concentrations. The transcript levels of enzymes involved in lipid metabolism (fatty acid synthase, glucose 6 phosphate dehydrogenase and carnitine palmitoyl transferase 1 a), gluconeogenesis (fructose-1,6-biphosphatase) and amino acid catabolism (alanine amino transferase and glutamate dehydrogenase) were significantly affected by the increase in dietary methionine. Changes in gene expression reflected to some extent the decrease in ammonia excretion (P=0.022) and in the hepatosomatic index (HSI; P
An optimized and simplified method for analysing urea and ammonia in freshwater aquaculture systems

This study presents a simple urease method for analysis of ammonia and urea in freshwater aquaculture systems. Urea is hydrolysed into ammonia using urease followed by analysis of released ammonia using the salicylate-hypochlorite method. The hydrolysis of urea is performed at room temperature and without addition of a buffer. A number of tests were performed on water samples obtained from a commercial rainbow trout farm to determine the optimal urease concentration and time for complete hydrolysis. One mL of water sample was spiked with 1.3 mL urea at three different concentrations: 50 lg L⁻¹, 100 lg L⁻¹ and 200 lg L⁻¹ urea-N. In addition, five concentrations of urease were tested, ranging from 0.1 U mL⁻¹ to 4 U mL⁻¹. Samples were hydrolysed for various time periods ranging from 5 to 120 min. A urease concentration of 0.4 U mL⁻¹ and a hydrolysis period of 120 min gave the best results, with 99.6–101% recovery of urea-N in samples spiked with 100 or 200 lg L⁻¹ urea-N.

The level of accurate quantification of ammonia using the method is 50 lg L⁻¹ NH₄⁺-N, and the detection level is 5–10 lg L⁻¹ NH₄⁺-N.

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Organisations: National Institute of Aquatic Resources, Section for Aquaculture
Authors: Larsen, B. K. (Intern), Dalsgaard, A. J. T. (Intern), Pedersen, P. B. (Intern)
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Effect of plant proteins and crystalline amino acid supplementation on postprandial plasma amino acid profiles and metabolic response in rainbow trout (Oncorhynchus mykiss)

The use of aquafeeds formulated with plant protein sources supplemented with crystalline amino acids (CAAs) is believed to influence amino acid (AA) uptake patterns and AA metabolic fate. Oxygen consumption and ammonia excretion rates were measured in rainbow trout (468.5 ± 86.5 g) force fed 0.75 % of their body mass with a diet based on either (1) fish meal (FM), (2) pea protein concentrate (PPC), or (3) pea protein concentrate supplemented with histidine, lysine, methionine and threonine (PPC+) to mimic FM AA profile. The specific dynamic action and nitrogen quotient (NQ) were calculated for 48 h of the postprandial period. In parallel, plasma AA concentrations were measured in blood samples withdrawn from the caudal vein before and then 2, 4, 6, 8, 12, 20, 32 and 48 h after feed administration. The unbalanced diet PPC had a significantly higher NQ compared to FM (0.29 ± A 0.09 and 0.18 ± A 0.04, respectively), and plasma profiles of essential AAs reflected the dietary deficiencies. Supplementation with CAA in diet PPC+ resulted in an intermediary NQ (0.21 ± A 0.04) and significantly affected plasma AA profiles, presenting greater and faster rises followed by sharp decreases compared to FM. The strongest effect was observed for methionine, presenting threefold higher concentrations at peak time for PPC+ compared to FM (297.0 ± A 77.0 and 131.8 ± A 39.0 nmol ml(-1), respectively). The differences in AA availability and metabolic profile in the pea diets compared to the FM diet were believed to be caused by an unbalanced dietary AA profile and CAA supplementation, rather than inclusion of plant protein concentrate.
Feed composition affects sludge as a resource for denitrification

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Organisations: National Institute of Aquatic Resources, Section for Aquaculture
Authors: Letelier-Gordo, C. O. (Intern), Larsen, B. K. (Intern), Dalsgaard, A. J. T. (Intern), Pedersen, P. B. (Intern)
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Improved growth performance in rainbow trout Oncorhynchus mykiss reared at high densities is linked to increased energy retention

Behaviour has been suggested as an underlying factor influencing how rearing density affects growth performance in Salmonid fishes. At low densities there is an elevated intensity of aggressive interactions and the formation of dominance hierarchies. As density increases, it is commonly assumed that aggression decreases, as the cost and effort required to establish and maintain dominance hierarchies increase. The increased energy expenditure associated with aggressive interactions has been identified as one mechanism causing a reduced efficiency in feed utilisation and therefore decreased growth performance. Manipulating aggressive behaviour through density may have advantages from a practical perspective. In the present study the energetic expenditure of rainbow trout held at three densities, 25, 80 and 140 kg m\(^{-3}\), were related to growth performance parameters. Measurements for growth performance and parameters of energetics were investigated at the three densities during a four week growth period. The results showed a significant increase in routine metabolism in fish reared at 25 kg m\(^{-3}\) compared to groups reared at higher densities. The study
concludes that in fish reared at density of 25 kg m(-3), a higher fraction of the dietary energy intake was used to fuel activity rather than growth, as evidenced by significantly higher routine metabolism, reduced feed utilisation efficiency and a tendency for lower growth performance compared to fish reared at the higher densities. These results indicate a bioenergetic advantage of crowding. (C) 2015 Published by Elsevier B.V.
Nitrogen waste from rainbow trout (Oncorhynchus mykiss) with particular focus on urea

Particulate and dissolved nitrogen (N) waste components are removed in recirculating aquaculture systems (RAS) using different cleaning technologies, and to dimension and optimize their removal efficiency requires that the expected daily load of the different waste forms can be estimated. Using a laboratory, mass-balance approach, the current study examined the effects of commercially applied feeding levels on the loading of different N waste forms, including daily fluctuations in dissolved total nitrogen (TN), total ammonia nitrogen (TAN), urea-N, and non-characterized, dissolved N deriving from juvenile rainbow trout (Oncorhynchus mykiss). In addition, the study examined whether there was a removal of urea-N across a moving bed biofilter operated as end-of-pipe under commercial conditions. The laboratory, mass-balance study showed that there were no effects of feeding levels (1.3, 1.5 or 1.7% of the biomass per day) on the excretion of dissolved N components, which constituted the majority of total N waste (>81.6% on average). The excretion of urea-N and non-characterized, dissolved N components constituted 12–13% and 9–11%, respectively of dissolved TN. The excretion of urea-N was largely constant and independent of the daily feeding practice, whereas that of non-characterized N appeared to reflect the daily feeding activity, following the trends in TN and TAN. The time limited feeding regime applied in the laboratory study resulted in a pulse in the excretion of TAN that a biofilter may be unable to fully level out, potentially resulting in unnoticed, critical water quality conditions in intensive RAS during certain times of the day. Particulate N waste constituted a minor fraction of total N waste (<18.4% on average), and the actual loading depended on the digestibility of dietary protein/nitrogen. Results from the commercially operated, nitrifying biofilter showed that urea-N was removed at a rate of 0.014 g N m⁻² day⁻¹. Compared to the removal of TAN (0.208 g N m⁻² day⁻¹), the moving bed biofilter was 1.07 times more active in removing dissolved N than immediately expected when only considering TAN.
Temperature and oxygen as determining factors in post-stress recovery profiles of Norwegian lobster Nephrops norvegicus

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Organisations: National Institute of Aquatic Resources, Section for Marine Ecology and Oceanography, Section for Aquaculture
Authors: Behrens, J. (Intern), Höglund, E. (Intern), Larsen, B. K. (Intern), Skov, P. V. (Intern)
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High oxygen consumption rates and scale loss indicate elevated aggressive behaviour at low rearing density, while elevated brain serotonergic activity suggest chronic stress at high rearing densities in farmed rainbow trout Oncorhynchus mykiss
The effect of stocking density on indicators of welfare has been investigated by several studies on farmed rainbow trout Oncorhynchus mykiss. However, the densities at which welfare are compromised remain ambiguous. Here three different stocking density treatments were selected based on the results of a previous study, where levels of crowding where determined using the spatial distribution of fish in two-tank systems. An un-crowded low density of 25 kg m\(^{-3}\), the highest density accepted by the fish without showing indications of crowding stress of 80 kg m\(^{-3}\) as the intermediate density, and the highest density accepted by the fish showing indications of crowding stress of 140 kg m\(^{-3}\) as the high density were investigated. The aim of the present study was to examine the effect of being held at these densities on indicators of welfare. This was achieved through oxygen consumption measurements using automated respirometry, recording fin erosion, determining scale loss and analysing plasma cortisol and brain serotonergic activity levels. The results obtained in the present study indicated that at the lowest density the fish had the space and opportunity to display their natural aggressive behaviour and that the fish held at the highest density were exposed to a situation of confinement.
Influence of inclusion level and form of dietary methionine in plant protein based diets on growth performances, ammonium excretion and postprandial methionine plasma levels in rainbow trout (Oncorhynchus mykiss).

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Authors: Rolland, M. (Intern), Larsen, B. K. (Intern), Holm, J. (Ekstern), Dalsgaard, A. J. T. (Intern), Skov, P. V. (Intern)
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Nitrogen waste load from juvenile rainbow trout (Oncorhynchus mykiss)

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Authors: Dalsgaard, A. J. T. (Intern), Larsen, B. K. (Intern), Pedersen, P. B. (Intern)
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Nutritional value of mussel meal in fish feed: a sustainable, high-quality protein source

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Perfluorinated compounds in fish and carryover from fishfeed to farmed rainbow trout
Perfluorooctanesulfonate (PFOS) and perfluorooctanoate (PFOA) bioaccumulate in humans and the half-life is around 4-6 years. As fish for many people is the largest source of PFOS exposure, the occurrence and the exposure of PFOS from fish was estimated. Today a significant proportion of the fish consumption is from aquaculture produce (~40% of the world’s fisheries (FAO 2012)). Hence the carryover of PFOS and PFOA from aquaculture feed to fish was studied.
In 2011 and 2012 fish were collected from Danish catching areas in the Baltic Sea and the North Sea and from Danish aquaculture farms and analysed for PFOS and PFOA.
The impact of chemical exposure on the cause in a feeding trial with rainbow trout (Oncorhynchus mykiss) accumulation and elimination of PFOS and PFOA was studied. PFOS was added to the fish feed at a level of 3 µg/g and PFOA at 0.5 µg/g. The fish were fed with the contaminated fish feed in an accumulation period of 12 weeks following an 8 weeks elimination period where unspiked feed were used. The feeding trials were carried out in tanks and the experiment included a control study of fish which were exposed only to unspiked feed. All feeding trials were conducted in duplicates. Fish were sampled 5 times during accumulation and 6 times during elimination. Analysis of PFOS and PFOA were performed on trout filet and liver.

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The effect of tryptophan supplemented diets on brain serotonergic activity and plasma cortisol under undisturbed and stressed conditions in grouped-housed Nile tilapia Oreochromis niloticus
Tryptophan (TRP) supplemented diets have been shown to have therapeutic effects in farmed animals including fish by modulating the activity of the neurotransmitter serotonin (5-hydroxytryptamine; 5-HT). The effects reported in fish have been obtained using individually-housed fish and include a reduction in stress response, aggression and stress-induced anorexia. In land farmed animals, TRP supplemented diets have also been shown to improve meat quality as a result of reduced stress during slaughter while in fish no data is currently available. This study aims at investigating whether short-term supplementation with TRP supplemented diets changes brain serotonergic activity and the stress response associated with slaughter handling in grouped-housed Nile tilapia Oreochromis niloticus. Adult fish (n. = 108, 490.6 ± 4.0 g, 12 individuals per tank) were exposed to one of the three treatments (triplicates per treatment were used): control (0.48 g/100 g), TRP 4. × (1.87 g/100 g) and TRP 10. × (4.45 g/100 g) diets during 7 days. Afterwards, half of the fish in each tank were subjected to an acute stressor consisting of a combination of crowding and chasing, just prior to slaughter. The other half of the fish represented undisturbed conditions. Blood and brain samples were collected for cortisol and serotonergic activity analyses, respectively. Flesh quality was also assessed in both undisturbed and stressed fish for all treatments by measuring muscle pH and rigor mortis over a 72 h period. Results showed that the highest TRP supplemented diet (TRP 10. ×) induced a significant reduction in undisturbed plasma cortisol (10.57 ± 2.71 ng/ml) as compared to TRP 4. × (24.93 ± 3.19 ng/ml) and control diets (18.69 ± 2.94 ng/ml) and no effect on post-stress cortisol levels. After stress, the major 5-HT metabolite (5-hydroxyindoleacetic acid, 5-HIAA) was higher in the TRP 10. × (471.31 ± 60.95 ng/g) as compared to the other diets (TRP 4. ×: 313.52 ± 30.12 ng/g; control: 260.36 ± 19.65 ng/g). Stress before slaughter induced a significant increase in plasma cortisol (from 18.40 ± 1.76 ng/ml under undisturbed conditions to 80.34 ± 7.16 ng/ml), however, it was not sufficient to cause a faster deterioration of flesh quality. TRP supplement diets had also no effect on muscle pH and rigor mortis during the 72 h observation period. In conclusion, this study showed that only the highest levels of supplementation (10. × the control diet) affect serotonergic activity. However, these levels did not result in reduced stress responsiveness or improved flesh quality when an acute stressor is applied before slaughter. Therefore, these results underline the fact that effects of TRP on cortisol production are dose- and context-dependent, and further experiments are needed to determine under which conditions the optimal effect is obtained.

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Authors: Martins, C. (Ekstern), Silva, P. (Ekstern), Costas, B. (Ekstern), Larsen, B. K. (Intern), Santos, G. (Ekstern), Conceicao, L. (Ekstern), Dias, J. (Ekstern), Øverli, T. (Ekstern), Höglund, E. (Intern), Schrama, J. (Ekstern)
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Effects of plant proteins on postprandial, free plasma amino acid concentrations in rainbow trout (Oncorhynchus mykiss)

Postprandial patterns in plasma free amino acid concentrations were investigated in juvenile rainbow trout (Oncorhynchus mykiss) fed either a fish meal based diet (FM) or a diet (VEG) where 59% of fish meal protein (corresponding to 46% of total dietary protein) was replaced by a matrix of plant proteins from wheat, peas, field beans, sunflower and soybean. Blood samples were obtained from the caudal vein of 7 fish in each dietary treatment group prior to feeding, as well as: 2, 4, 6, 8, 12, 24, 48 and 72 h after feeding (sampling 7 new fish at each time point), and plasma amino acid concentrations were subsequently measured by HPLC. Nutrient digestibility and ammonia excretion of the two experimental diets were measured in a parallel experiment using a modified Guelph setup. Results showed that the appearance of most amino acids (essential and non-essential) in the plasma was delayed in fish fed the VEG diet compared to those fed the FM diet. Essential and non-essential amino acids furthermore appeared more or less synchronously in the plasma in fish fed the FM diet, while the appearance was less synchronised in fish fed the VEG diet. Differences in plasma concentrations between the two dietary treatment groups correlated largely with the amino acid content of the two diets except for methionine, lysine and arginine, where the differences were more extreme than what would be expected from differences in dietary concentrations. The apparent protein digestibility coefficient was higher in the VEG diet than in the FM diet (93 versus 92%; t-test, P<0.05), supporting that protease inhibitors from plant protein ingredients were not the cause of the delay. The apparent digestibility coefficient of carbohydrates (calculated as nitrogen-free extract (NFE)) was much lower in the VEG than in the FM diet (51 versus 76%; t-test, P<0.05). Combined with a higher NFE content in the VEG diet, this meant that there was 2.7 times more indigestible NFE in the VEG than in the FM diet (6.1 versus 2.2 g 100−1 g feed). Such difference may suggest that the uptake of amino acids (AA) was affected by dietary carbohydrates. Total ammonia-nitrogen (TAN) excretion was slightly, but non-significantly, higher in VEG fed fish than in FM fed fish (59 versus 55 mg TAN g−1 digested protein; t-test, P>0.05). In conclusion, the study showed that amino acid uptake patterns are affected when replacing fish meal with plant based protein ingredients.
Effects of stocking density and sustained aerobic exercise on growth, energetics and welfare of rainbow trout

Two stocking densities, “low” (L, between ~19 and ~25 kgm⁻³) and “high” (H, between ~75 and ~100 kgm⁻³) were compared for effects on specific growth rate (SGR), feed conversion, energetics and welfare of rainbow trout reared at 14 °C either in static water (S) or swimming in a gentle current of ~0.9 bodylengths s⁻¹ (C). Trout (initial mass ~110 g) were reared for 9 weeks in circular tanks (volume 0.6 m³), in triplicate of four conditions (LS, LC, HS, HC). Fish were fed ad libitum daily; waste pellets were swirl-collected at the outflow to calculate feed intake. SGR was measured each three weeks for the last six weeks of the trial. The tanks functioned as intermittent-stopped flow respirometers, to permit metabolic rate to be measured as instantaneous oxygen uptake once per hour. Mean (±SD) SGR was significantly lower at H than L (1.51±0.03% vs 1.44±0.04% day⁻¹, respectively, n=6) and lowest in HC. When compared over a similar interval of mass gain, H groups had approximately 25% higher metabolic rates than L, with the highest rates in the HC condition. As a result, fish in the H groups dissipated a greater amount of feed energy as metabolism and, across all groups, there was a direct negative relationship between the quantity of energy dissipated and their SGR. There was no evidence of a neuroendocrine stress response, plasma cortisol was around 1 ng ml⁻¹ in all conditions. An acute crowding stress increased plasma cortisol to above 120 ng ml⁻¹ in all groups, but C groups recovered to control levels within 8 h whereas S groups required 20 h. Respirometry on individuals revealed that H fish had approximately 14% higher metabolic rates than L fish, indicating that increased metabolic rate in rearing tanks was in part physiological. The H groups had approximately 15% lower critical swimming speeds than the L groups which, together with their raised metabolic rate, indicated a physiological impairment. Thus, high density reduced SGR by raising energy dissipation, at least partially as a physiological response by the fish, although there was no evidence of an endocrine stress response. The only beneficial effect of C was in recovery from acute stress.
Influence of protein source on amino acid uptake patterns and protein utilization in rainbow trout Oncorhynchus mykiss

Matrixes of different protein sources (fish and plant products) combined with the use of crystalline amino acids allow for formulation of diets that meet fish requirements with little or no effect on protein digestibility and/or feed intake. Despite this, a total or partial replacement of fish meal induces reduced growth performances that remain partly unexplained. The aim of the current study was to investigate the effect of exchanging the protein source on protein utilization. Marine (fish meal) and vegetable (pea protein) sources were used with or without supplementation of crystalline amino acids to the fishmeal diet level (see Table 1). Amino acid uptake patterns were assessed by the appearance of amino acids in the blood stream following the ingestion of a meal, while dietary protein utilization was evaluated by examining the metabolic response to digestion and ammonium and urea excretion rates during digestion. Four treatments, 3 diets and 1 control (no feeding), were applied to rainbow trout with an average body mass of 500 grams. Fish were either force fed one of the 3 diets at a ration corresponding to 0.75% of the body mass, or no force feeding. Four fish at a time (one per treatment) were placed in individual chambers for 48h. Blood and water samples were collected at time 0 and then at 2, 4, 6, 8, 12, 20, 32 and 48 hours post feeding. The protocol was repeated until 8 replicates per treatment were obtained.

The results were obtained through 2 separate experiments.

In the first part, oxygen consumption was recorded continuously, while water was sampled as detailed above and analyzed for ammonium and urea content.

The second part of the experiment was designed to collect blood samples. After the feeding treatment fish were held in separate containers for the above described time sampling. Fish were killed by a blow in the head and blood was collected from the caudal vein with heparinized syringes. Plasma and red blood cells content were stored separately at -80 for amino acid content analysis.

The ammonium excretion profiles (Figure 1) will be correlated with the amino acid profile in the blood and oxygen consumption during digestion to investigate the effect on protein utilization for each treatment.

General information

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Main Research Area: Technical/natural sciences
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The effects of stocking density and low level sustained exercise on the energetic efficiency of rainbow trout (Oncorhynchus mykiss) reared at 19°C

A 9 week growth trial was performed at two rearing densities; low (~25 kg m−3) and high (~100 kg m−3), in combination with either static water or a water current corresponding to 0.9 body lengths s−1, to investigate the effects of density and exercise on the bioenergetics of rainbow trout reared at 19 °C, particularly routine metabolic rate (RMR), specific growth rate (SGR), and feed conversion ratio (FCR). The growth trial showed that high rearing density resulted in significantly lower SGR and increased FCR, with no significant alleviating effects of awater current, although slight improvement in both parameters were observed at lowdensity. A significant linear relationship between SGR and FCR suggested that increased energy expenditurewas the primary cause of reduced growth. Hourly measurements of instantaneous oxygen uptake, during a period of similar growth (200–350 g), revealed clear effects of the experimental conditions. Energetic budgets were calculated from feed intake and routinemetabolic rate (RMR) and revealed that whilst feed intakewas similar...
for all groups, a higher RMR in the high density groups resulted in a higher daily rate of energy utilization for routine activity, leading to slower growth. However, a lower RMR in fish subjected to a current resulted in a greater proportion of energy being retained, leading to significantly higher SGR for the selected period, at both low and high density. Furthermore, the presence of a water current was observed to induce schooling behaviour, which is known to reduce aggression and stress. It is thereby likely that the presence of a current had a positive effect on welfare in addition to its effect on energy metabolism. We conclude that the presence of a water current to some extent could alleviate the negative effects of high density at 19 °C, a relatively high temperature experienced in farming of rainbow trout during hot seasons.

General information

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Scopus rating (2009): SJR 0.941 SNIP 1.263
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Scopus rating (2007): SJR 1.019 SNIP 1.318
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.008 SNIP 1.689
An estrogen-responsive plasma protein expression signature in Atlantic cod (Gadus morhua) revealed by SELDI-TOF MS

Compound-specific protein expression signatures (PESs) can be revealed by proteomic techniques. The SELDI-TOF MS approach is advantageous due to its simplicity and high-throughput capacity, however, there are concerns regarding the reproducibility of this method. The aim of this study was to define an estrogen-responsive PES in plasma of Atlantic cod (Gadus morhua) using the SELDI-TOF MS technique. Protein expression analysis of male cod exposed to 17 β-estradiol (E2) showed that 27 plasma peaks were differentially expressed following exposure. The reproducibility of this result was evaluated by reanalyzing the samples six months later, and a significant change in expression was confirmed for 13 of the 27 peaks detected in the first analysis. The performance of the reproducible E2-responsive PES, constituting these 13 peaks, was then tested on samples from juvenile cod exposed to 4-nonylphenol, North Sea oil, or North Sea oil spiked with alkylphenols. Principal component analysis revealed that nonylphenol-exposed cod could be separated from unexposed cod based on the E2-responsive PES, indicating that the PES can be used to assess estrogenic exposure of both juvenile and adult specimens of cod. A targeted antibody-assisted SELDI-TOF MS approach was carried out in an attempt to identify the E2-responsive peaks. Results indicated that 2 peaks were fragments of the well-known biomarkers VTG and/or ZRP. In this study, the SELDI-TOF MS technology has shown its potential for defining compound-specific PESs in fish. Nevertheless, thorough validation of reproducibility, specificity, and sensitivity of a PES is required before it can be applied in environmental monitoring.
Effects of rearing density and water current on the respiratory physiology and haematology in rainbow trout, *Oncorhynchus mykiss* at high temperature

**General information**
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Authors: Skov, P. V. (Intern), Larsen, B. K. (Intern), Frisk, M. (Ekstern), Jokumsen, A. (Intern)
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Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.294 SNIP 1.542 CiteScore 2.39
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Scopus rating (2010): SJR 1.151 SNIP 1.394
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Scopus rating (2007): SJR 1.019 SNIP 1.318
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Scopus rating (2005): SJR 0.915 SNIP 1.236
Web of Science (2005): Indexed yes
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Scopus rating (2003): SJR 1.121 SNIP 1.926
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 0.992 SNIP 1.418
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 1.049 SNIP 1.317
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Chronic exposure of adults and embryos of Pandalus borealis to oil causes PAH accumulation, initiation of biomarker responses and an increase in larval mortality

General information
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Organisations: Section for Aquaculture, National Institute of Aquatic Resources, Center for Biological Sequence Analysis, Department of Systems Biology
Authors: Bechmann, R. (Ekstern), Larsen, B. K. (Intern), Taban, I. (Ekstern), Hellgren, L. (Intern), Møller, P. (Intern), Sanni, S. (Ekstern)
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Scopus rating (2015): SJR 1.245 SNIP 1.277 CiteScore 3.23
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Scopus rating (2014): SJR 1.304 SNIP 1.425 CiteScore 3.04
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Scopus rating (2013): SJR 1.208 SNIP 1.546 CiteScore 2.89
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.241 SNIP 1.377 CiteScore 2.64
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.248 SNIP 1.336 CiteScore 2.57
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Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.284 SNIP 1.284
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.302 SNIP 1.202
Web of Science (2009): Indexed yes
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Scopus rating (2008): SJR 1.366 SNIP 1.336
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Scopus rating (2007): SJR 1.333 SNIP 1.343
Organic vegetable proteins and oil in feed for organic rainbow trout (Oncorhynchus mykiss)

The demand for organic trout is increasing, stressing the need for organic, vegetable feed ingredients as replacement for fish meal, as the principles of organic aquaculture encourage the development of feed that do not deplete global fish stocks. In addition, the organic code of practice does not allow addition of artificial amino acids to the feed, and optimization of the amino acid profile of organically based diets must therefore derive from the protein sources alone. The aim of this study was to evaluate the digestibility and growth performance of organic vegetable dietary ingredients as replacement for fish meal and fish oil in feed for organic rainbow trout (Oncorhynchus mykiss). Six iso-energetic and iso-nitrogenous diets were prepared, comprising a fish meal and fish oil based control diet and three diets in which the inclusion of fish meal was gradually reduced from 59 to 35 % and replaced by a matrix of organic horse bean, pea and rape in the proportion of 1:1:0.7. In the last two diets, the inclusion of fish oil was reduced by 50 and 100 %, respectively and replaced by flax seed oil high in omega-3 fatty acids. Digestibility was measured directly using a modified, flow-through Guelph System consisting of 18 tanks, and feeding each diet in triplicate. Growth performance was measured using a recirculation system consisting of 12 square formed fibre glass tanks. The fish were reared in duplicate for 9 weeks, from an initial individual weight of about 60 g to a final weight of about 200 g. The fish showed good growth performance with a specific growth rate (SGR) of 1.8 % d⁻¹, and a feed conversion ratio (FCR) of 0.75, and there were no significant differences between the groups. Likewise, there were no significant differences in nutrient digestibility between the diets. The results indicate that a matrix of organic horse bean, pea and rape may partially replace fish meal, and flax seed oil may replace fish oil in feed for organic rainbow trout without compromising growth performance and feed utilization.

Enzymatic and cellular responses in relation to body burden of PAHs in bivalve molluscs: A case study with chronic levels of North Sea and Barents Sea dispersed oil

General information
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Organisations: International Research Institute of Stavanger
Authors: Baussant, T. (Ekstern), Bechmann, R. (Ekstern), Taban, I. (Ekstern), Larsen, B. K. (Intern), Tandberg, A. (Ekstern), Bjernstad, A. (Ekstern), Torgrimsen, S. (Ekstern), Naevdal, A. (Ekstern), Oysaed, K. (Ekstern), Jonsson, G. (Ekstern), Sanni, S. (Ekstern)
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DNA damage in mussels following exposure to three potential endocrine disruptors using the comet assay and the alkaline unwinding assay

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Organisations: Unknown
Authors: Aas, E. (Ekstern), Bechmann, R. (Ekstern), Larsen, B. K. (Intern), Barsiene, J. (Ekstern), Lazutka, J. (Ekstern), Sanni, S. (Ekstern)
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An ecotoxicoproteomic approach (SELDI-TOF mass spectrometry) to biomarker discovery in crab exposed to pollutants under laboratory conditions

Ciphergen ProteinChip Technology (TM) is a proteomic tool, used for the discovery of new and sensitive biomarkers. This approach was used to evaluate the protein profile of crabs exposed to various pollutants. Two different exposure experiments were performed: spider crabs (Hyas araneus) were exposed for 3 weeks to diallyl phthalate (DAP), bisphenol A (BisA) and polybrominated diphenyl ether (PBDE-47), while shore crabs (Carcinus maenas) were exposed to crude oil, crude oil spiked with alkylphenols (APs) and 4-nonylphenol (NP). Gender and species-related protein pattern alterations were observed and compared to controls. Results showed different responses to pollutants by the two species. Major disruption in protein peak expression was observed in samples exposed to mixtures of pollutants, i.e. oil spiked with APs. Compared to shore crab, spider crab species showed a lower degree of response in terms of number of altered protein peaks following exposure. In general, female individuals of both species showed a larger number of significantly altered proteins compared to males. Data analysis by non-metric multi-dimensional scaling (MDS) was performed. Bi-dimensional-MDS plots revealed a good separation of groups for both spider and shore crabs. In some cases, a good discrimination can also be observed between the two genders within each treatment.

Results highlight the potential of crabs as sentinel organisms for the aquatic environment. The results indicate that SELDI-ToF technology is a powerful tool to discover protein expression signatures for different pollutants and sex dependent responses. (c) 2006 Elsevier B.V. All rights reserved.
Comparison of protein expression in plasma from nonylphenol and bisphenol A exposed juvenile Atlantic cod (Gadus morhua) and turbot (Scophthalmus maximus)

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ISI indexed (2012): ISI indexed yes
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Preliminary study of responses in mussel (Mytilus edulis) exposed to bisphenol A, diallyl phthalate and tetrabromodiphenyl ether

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Organisations: University of Bordeaux, Technische Universität Berlin, International Research Institute of Stavanger
Authors: Aarab, N. (Ekstern), Lemaire-Gony, S. (Ekstern), Unruh, E. (Ekstern), Hansen, P. (Ekstern), Larsen, B. K. (Intern), Andersen, O. (Ekstern), Narbonne, J. (Ekstern)
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BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.666 SNIP 1.175 CiteScore 3.79
Web of Science (2015): Indexed yes
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The BEEP Stavanger Workshop: Mesocosm exposures

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Scopus rating (2014): SJR 0.849 SNIP 0.949 CiteScore 2.19
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ISI indexed (2013): ISI indexed yes
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Scopus rating (2012): SJR 0.702 SNIP 0.741 CiteScore 1.8
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BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.794 SNIP 0.779 CiteScore 1.85
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.926 SNIP 0.756
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.819 SNIP 0.761
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.814 SNIP 0.708
Scopus rating (2007): SJR 0.73 SNIP 0.792
Scopus rating (2006): SJR 0.81 SNIP 0.769
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.913 SNIP 0.913
Scopus rating (2004): SJR 0.657 SNIP 0.765
Scopus rating (2003): SJR 0.668 SNIP 0.843
Scopus rating (2002): SJR 0.635 SNIP 0.817
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.659 SNIP 0.785
Scopus rating (2000): SJR 0.501 SNIP 0.794
Scopus rating (1999): SJR 0.482 SNIP 1.017
Original language: English
Source: orbit
A proteomic (SELDI-TOF MS) approach to ecotoxicological research

General information
State: Published
Organisations: International Research Institute of Stavanger
Authors: Lyng, E. (Ekstern), Larsen, B. K. (Intern), Bjørnstad, A. (Ekstern), Pampanin, D. M. (Ekstern), Andersen, O. K. (Ekstern)
Publication date: 2005
Event: Poster session presented at SETAC UK 2005 - "Chronic and Diffuse Pollution", Newcastle, United Kingdom.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 279070
Publication: Research › Poster – Annual report year: 2005

BIOSEA JIP – development of a global biomonitoring tool for the petroleum industry offshore

General information
State: Published
Organisations: International Research Institute of Stavanger
Authors: Sanni, S. (Ekstern), Buffagni, M. (Ekstern), Moltu, U. (Ekstern), Kelley, A. (Ekstern), Bracco, L. (Ekstern), Pinturier, L. (Ekstern), Baussant, T. (Ekstern), Larsen, B. K. (Intern), Bechmann, R. (Ekstern), Skadsheim, A. (Ekstern), Sundt, R. (Ekstern), Aas, E. (Ekstern), Beyer, J. (Ekstern), Børseth, J. (Ekstern)
Publication date: 2005
Event: Poster session presented at The Offshore Mediterranean Conference and Exhibition, Ravenna, Italy.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 279067
Publication: Research › Poster – Annual report year: 2005

Biochemical and histological responses in mussel (Mytilus edulis) exposed to North Sea oil and to a mixture of North Sea oil and alkyl/phenols

General information
State: Published
Organisations: University of Bordeaux, University of Le Havre, Technische Universität Berlin, Rogaland Research
Authors: Aarab, N. (Ekstern), Minier, C. (Ekstern), Lemaire, S. (Ekstern), Unruh, E. (Ekstern), Hansen, P. (Ekstern), Larsen, B. K. (Intern), Andersen, O. (Ekstern), Narbonne, J. (Ekstern)
Pages: 437-441
Publication date: 2004
Main Research Area: Technical/natural sciences

Publication information
Journal: Marine Environmental Research
Volume: 58
Issue number: 2-5
ISSN (Print): 0141-1136
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.24 SJR 1.092 SNIP 1.083
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.103 SNIP 1.103 CiteScore 3.15
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.95 SNIP 1.109 CiteScore 2.67
DNA damage in mussels following exposure to three potential endocrine disruptors using the comet assay and the alkaline unwinding assay

General information
State: Published
Organisations: Unknown
Authors: Taban, I. (Ekstern), Bechmann, R. (Ekstern), Torgrimsen, S. (Ekstern), Sundt, R. (Ekstern), Bjørnstad, A. (Ekstern), Larsen, B. K. (Intern), Andersen, O. (Ekstern)
Publication date: 2003
Event: Poster session presented at at BEEP Workshop, Barcelona, Spain, .
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 267793
Publication: Research › Poster – Annual report year: 2003

Assessment of DNA damage in mussels, crabs and fish

General information
State: Published
Organisations: International Research Institute of Stavanger
Authors: Bjørnstad, A. (Ekstern), Larsen, B. K. (Intern), Taban, I. (Ekstern), Bechmann, R. (Ekstern), Torgrimsen, S. (Ekstern), Andersen, O. (Ekstern)
Publication date: 2002
Event: Poster session presented at BEEP Workshop, Athens, Greece,. .
Main Research Area: Technical/natural sciences
Source: orbit
Effect of cortisol and urea on flavin monooxygenase activity and expression in rainbow trout, Oncorhynchus mykiss

General information
State: Published
Organisations: University of California, Riverside
Authors: El-Alfy, A. (Ekstern), Larsen, B. K. (Intern), Schlenk, D. (Ekstern)
Pages: 275-278
Publication date: 2002
Main Research Area: Technical/natural sciences

Publication information
Journal: Marine Environmental Research
Volume: 54
Issue number: 3-5
ISSN (Print): 0141-1136
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.24 SJR 1.092 SNIP 1.083
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.103 SNIP 1.103 CiteScore 3.15
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.95 SNIP 1.109 CiteScore 2.67
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 0.969 SNIP 1.12 CiteScore 2.48
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 0.93 SNIP 1.241 CiteScore 2.4
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 0.896 SNIP 1.07 CiteScore 2.17
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 0.833 SNIP 0.851
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 0.831 SNIP 0.901
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 0.993 SNIP 1.067
Scopus rating (2007): SJR 0.888 SNIP 0.838
Scopus rating (2006): SJR 1.355 SNIP 1.236
Scopus rating (2005): SJR 0.763 SNIP 0.847
Scopus rating (2004): SJR 1.3 SNIP 1.506
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.82 SNIP 0.942
Scopus rating (2002): SJR 0.717 SNIP 1.271
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.662 SNIP 0.722
Scopus rating (2000): SJR 1.114 SNIP 1.088
Web of Science (2000): Indexed yes
Effect of Salinity on Flavin-containing Monooxygenase expression and activity in rainbow trout (Oncorhynchus mykiss)

General information
State: Published
Organisations: University of California
Authors: Larsen, B. K. (Intern), Schlenk, D. (Ekstern)
Pages: 421-429
Publication date: 2001
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Comparative Physiology B
Volume: 171
Issue number: 5
ISSN (Print): 0174-1578
Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): SJR 0.867 SNIP 0.887 CiteScore 2.02
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.126 SNIP 0.991 CiteScore 2.21
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.16 SNIP 1.018 CiteScore 2.35
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.987 SNIP 0.97 CiteScore 2.39
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.768 SNIP 0.861 CiteScore 2.02
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.944 SNIP 0.956 CiteScore 2.02
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.903 SNIP 0.946
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.775 SNIP 0.903
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.849 SNIP 0.842
Scopus rating (2007): SJR 0.754 SNIP 0.919
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.696 SNIP 0.929
Scopus rating (2005): SJR 0.609 SNIP 0.835
Scopus rating (2004): SJR 0.706 SNIP 0.922
Scopus rating (2003): SJR 0.578 SNIP 0.916
Scopus rating (2002): SJR 0.641 SNIP 0.835
Scopus rating (2001): SJR 0.519 SNIP 0.838
Effect of urea and low temperature on the expression and activity of flavin-containing monooxygenase in the liver and gill of rainbow trout (Oncorhynchus mykiss)

General information
State: Published
Organisations: University of California
Authors: Larsen, B. K. (Intern), Schlenk, D. (Ekstern)
Pages: 19-29
Publication date: 2001
Main Research Area: Technical/natural sciences

Publication information
Journal: Fish Physiology & Biochemistry
Volume: 25
Issue number: 1
ISSN (Print): 0920-1742
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.7 SJR 0.562 SNIP 0.821
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.736 SNIP 0.918 CiteScore 1.59
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.652 SNIP 0.891 CiteScore 1.77
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.708 SNIP 0.952 CiteScore 1.72
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.6 SNIP 1.192 CiteScore 1.76
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.659 SNIP 1.033 CiteScore 1.6
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.506 SNIP 0.858
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.444 SNIP 0.703
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.34 SNIP 0.54
Scopus rating (2007): SJR 0.253 SNIP 0.331
Scopus rating (2006): SJR 0.304 SNIP 0.389
Scopus rating (2005): SJR 0.406 SNIP 0.426
Scopus rating (2004): SJR 0.248 SNIP 0.246
**Target organ toxicity in the kidney**

**General information**
State: Published
Organisations: Unknown
Authors: Larsen, B. K. (Intern), Perkins, E. (Ekstern)
Pages: 102-164
Publication date: 2001

**Host publication information**
Title of host publication: Target Organ Toxicity in Marine and Freshwater Teleosts
Volume: 1: Organs
Place of publication: London
Publisher: Taylor and Francis
Editors: Benson, W., Schlenck, D.
ISBN (Print): 0-415-24838-8
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 267788
Publication: Research - peer-review › Book chapter – Annual report year: 2001

**Estrogenic and CYP1A response of mummichogs and sunshine bass to sewage effluent**

**General information**
State: Published
Organisations: State University of New York, University of Mississippi
Authors: McArdle, M. (Ekstern), Elskus, A. (Ekstern), McElroy, A. (Ekstern), Larsen, B. K. (Intern), Benson, W. (Ekstern), Schlenk, D. (Ekstern)
Pages: 175-179
Publication date: 2000
Main Research Area: Technical/natural sciences

**Publication information**
Journal: Marine Environmental Research
Volume: 50
Issue number: 1-5
ISSN (Print): 0141-1136
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.24 SJR 1.092 SNIP 1.083
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.103 SNIP 1.103 CiteScore 3.15
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.95 SNIP 1.109 CiteScore 2.67
Extra and Intracellular acid-base balance and ionic regulation in cod (Gadus morhua) during combined and isolated exposures to hypercapnia and copper

General information
State: Published
Organisations: Alfred Wegener Institute for Polar and Marine Research, University of Southern Denmark
Authors: Larsen, B. K. (Intern), Pörtner, H. (Ekstern), Jensen, F. (Ekstern)
Pages: 337-346
Publication date: 1997
Main Research Area: Technical/natural sciences

Publication information
Journal: Marine Biology
Volume: 128
ISSN (Print): 0025-3162
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.41 SJR 1.198 SNIP 0.993
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.315 SNIP 0.932 CiteScore 2.21
Influence of ionic composition on acid-base regulation in rainbow trout (Oncorhynchus mykiss) exposed to environmental hypercapnia

General information
State: Published
Organisations: Odense University
Authors: Larsen, B. K. (Intern), Jensen, F. (Ekstern)
Pages: 157-170
Publication date: 1997
Effects of freshwater to seawater transfer on osmoregulation, acid base balance and respiration in river migrating whitefish (Coregonus lavaretus)

General information
State: Published
Organisations: University of Southern Denmark
Arterial $PO_2$, acid-base status, and red cell nucleoside triphosphates in rainbow-trout transferred from fresh water to 20-percent sea water

**General information**
State: Published
Organisations: University of Southern Denmark
Authors: Larsen, B. K. (Intern), Jensen, F. (Ekstern)
Pages: 611-614
Publication date: 1993
Main Research Area: Technical/natural sciences

**Publication information**
Journal: Journal of Fish Biology
Volume: 42
Issue number: 4
ISSN (Print): 0022-1112
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.57 SJR 0.741 SNIP 0.882
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.951 SNIP 0.935 CiteScore 1.64
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.944 SNIP 0.934 CiteScore 1.76
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.049 SNIP 1.118 CiteScore 1.98
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.93 SNIP 1.035 CiteScore 1.88
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.895 SNIP 0.946 CiteScore 1.66
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.774 SNIP 0.834
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.773 SNIP 0.891
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 0.883 SNIP 0.968
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.996 SNIP 1.06
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.897 SNIP 1.051
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.827 SNIP 0.898
Projects:

Resource efficiency in practice: from sugar beet waste to fish feed ingredient (Starfish) (39368)
Sugar beet is a commonly cultivated crop in Denmark and the waste pulp is primarily sold as cow feed. The pulp, however, contains a potential prebiotic compound (pectin) that, if added to fish feed at low concentrations is hypothesized to:
1) improve the feed utilisation by the fish allowing more fish to be produced per amount of feed applied
2) stabilize the structure of the faecal waste so that it may be easier collected and removed reducing the discharge of nitrogen- and phosphorous
3) improve the overall immunological system/health status of the fish whereby the use of medicine and therapeutics may be reduced.

The objective of the project is to test these potential, beneficial effects of pectin in rainbow trout (Oncorhynchus mykiss) and tilapia (Oreochromis niloticus) by adding different molecular sizes and concentrations to the feed and measuring the effects on feed utilisation, faecal structure and fish health.

The project is coordinated by DTU Aqua.
The project is funded by Ministry of Environment and Food of Denmark through the Green Development and Demonstration Program (GUDP).

National Institute of Aquatic Resources
Section for Aquaculture
CP Kelco ApS
BioMar A/S
Period: 01/08/2016 → 31/07/2019
Number of participants: 4
Research area: Aquaculture
Project participant:
Larsen, Bodil Katrine (Intern)
Skov, Peter Vilhelm (Intern)
PhD Student:
de Jesus Gregersen, Joao (Intern)
Project Coordinator:
Dalsgaard, Anne Johanne Tang (Intern)

HPLC – Implementation of new analytical methods (39227)
This is an internally funded project with the purpose of developing and implementing new analytical methods aimed at determining indicators for growth i.e. protein metabolism and synthesis, and includes amino acids and ATP, ADP, AMP in tissue. It is investigated whether a developed technique can be implemented. We will investigate, whether we can use a western blotting technique to enable us to estimate to which degree protein synthesis is stimulated, more specifically by measuring the degree of phosphorylation of certain markers within the mTOR signaling pathway. In addition, selected marker(s) of protein degradation is included. This will enable us to obtain an in-depth knowledge regarding protein
synthesis/turnover and protein utilization in fish. We thereby presume to be able to investigate and document which/how nutritional factors (e.g. new protein sources & specific amino acids) and rearing conditions (e.g. feeding strategy, water quality, exercise, stress etc.) affect protein turnover (and thereby growth) in fish. The relationship between growth/protein utilization and mTOR response needs to be investigated further, but potentially this technique may e.g. allow us to compare a large number of diets and very quickly determine the response in muscle tissue. This means that a large number of diets can be screened without the cost of large and long-lasting growth trials, and it may become faster/easier to select the most optimal diets based on the response. As growth and growth efficiency are vital factors in aquaculture, the method might have great potential under a variety of circumstances.

This project is coordinated by DTU Aqua.
The project is internally funded.

National Institute of Aquatic Resources
Section for Aquaculture
Period: 01/01/2016 → …
Number of participants: 1
Research area: Aquaculture
Project participant:
Larsen, Bodil Katrine (Intern)

Proteins of the future in feed for recirculating aquaculture systems (ProffAqua) (39274)

There is an increasing shortage of available high quality proteins for feed. More than half of all aquatic species is now produced by aquaculture. Aquaculture production will double in the next 15 years and so will the need for protein into aquafeed. As substantial amount of worldwide wild fish catch is processed into fishmeal and fish oil for feed production, raising concerns regarding the sustainability of this arrangement. The industry’s growing need for feed therefore requires new approaches. This project focuses on turning waste streams into valuable products. Organic chemicals found in pulp mills streams for cellulose fibre production can be used to grow fungi and turned into Single Cell Proteins (SCP), suitable as protein-rich components in fish feed. Due to the low protein content of waste materials from agriculture and fish processing, this raw material is not suitable for direct use in fish feed. The black soldier fly larvae (BSF) are very efficient in transforming such waste streams into high quality protein and oil ingredients. Based on the available waste streams, several thousand tonnes of both SCP and BSF can be produced at a very favourable price compared to the current price and quality of fish meal.

The role of DTU Aqua in the project is to evaluate BSF and SCP as protein sources in fish feeds by performing digestibility and growth trials using the two types of protein sources at several inclusion level in the diets.

DTU Aqua participates in the project by performing feeding trials using contaminated feed for Atlantic salmon and seabass respectively. Furthermore, the project also investigates potential effects of microplastic incorporated into feed pellets, on accumulation and elimination of the selected priority contaminants. The feeding trials consist of a 12 week to 15 week accumulation period for seabass and salmon respectively and a 8 week depuration period where all groups are fed control feed. The results obtained from the trail will be the used to develop mathematical models estimating accumulation and elimination of priority contaminants in filet.

This project is coordinated by Matís Itd., Icelandic Food and Biotech R&D.
This project is funded by Nordforsk, Nordic Council of Ministers.

National Institute of Aquatic Resources
Section for Aquaculture
Matís Ltd.
SP Processum AB
Danish Technological Institute
Veðurstofa Íslands
Domsjö Fabriker AB
Tydalfisk
Period: 01/02/2015 → 31/12/2017
Number of participants: 6
Research area: Aquaculture
Project participant:
Larsen, Ole Madvig (Intern)
Jensen, Rasmus Frydenlund (Intern)
Vega, Victoria Valdenegro (Intern)
New physicochemical and technological approach for high quality and sustainable fish feed production (Exipro) (39189)

Aquaculture is the globally fastest growing food producing sector, and extruded fish feed is the largest expenditure in the production of carnivorous fish.

The quality of the different protein raw materials used in fish feed varies considerably, and even small differences in the nutritional quality can have large effects on fish performance, their degree of feed utilization and consequently the environment.

The production of high quality, nutrient-dense fish feed requires that the dietary matrix is extruded into pellets. However, the extrusion process can alter and deteriorate the nutritional quality of proteins. Currently, the extrusion process is based entirely on empirical learning, and little is known about the chemical reactions and physical processes that take place inside the extruder, i.e., the extruder is largely a ‘Black Box’. In addition, little is known about concomitant effects on feed utilization.

The aim of Exipro is to optimize the extrusion process by clarifying the changes and damages on different protein ingredients that happen in the extruder, and to use the knowledge to improve the quality of fish feed. Hence, the objectives of the project are to:
- Determine the effects of extrusion on the physicochemical and chemical properties of proteins in fish feed
- Determine the effects of these changes on fish growth performance, metabolism, protein retention, and nitrogen excretion
- Develop a generic extrusion optimization tool for different protein ingredients.

The project is coordinated by University of Copenhagen.

The project is funded by Innovation Fund Denmark.

National Institute of Aquatic Resources
Section for Aquaculture
University of Copenhagen
Aarhus University
BioMar A/S
Period: 01/09/2014 → 31/12/2017
Number of participants: 3
Research area: Aquaculture
Project participant:
Larsen, Bodil Katrine (Intern)
Vega, Victoria Valdenegro (Intern)
Project Manager, academic:
Dalsgaard, Anne Johanne Tang (Intern)
Project

Sustainable fish feed development in Ghana (Susfeed) (39158)

The overall objective of the project is to enable Kwame Nkrumah University of Science and Technology (KNUST) to serve as a centre of excellence for sustainable development of aquaculture and to take a scientific approach to the continued improvement of fish feed formulation using local raw materials, through controlled experiments and in collaboration with the private sector in Ghana. The immediate objectives of the project are to formulate cost effective tilapia feeds assessed for digestibility, nutritional value and amino acid profiles based on local feed ingredients; to facilitate the growth of the tilapia aquaculture industry in Ghana through promoting the production and application of locally developed high quality feeds; to achieve a zero change in nutrient discharge to the environment through the application of balanced feed and efficient feeding strategies; and to improve the methodological and scientific capacity at KNUST to provide a platform of excellence in research and teaching.

The project is funded by DANIDA, Ministry of Foreign Affairs of Denmark.

National Institute of Aquatic Resources
Seafood has been recognized as a high-quality, healthy and safe food type and is one of the most important food commodities consumed worldwide. However, seafood, like other types of food, can also be a source of harmful environmental contaminants with potential to impact on human health.

ECsafeSEAFOOD will assess food safety issues related to priority contaminants present in seafood as a result of environmental contamination (including those originating from harmful algal blooms and those associated with marine litter) and evaluate their impact on public health. ECsafeSEAFOOD will provide scientific evidence to serve as a basis for further development of common food safety, public health and environmental policies and measures, by seeking to establish a quantitative link between the contamination of the marine environment and that of seafood.

www.ecsafeseafood.eu

National Food Institute
Division of Food Chemistry
National Institute of Aquatic Resources

Section for Aquaculture
Period: 15/02/2013 → 15/02/2017
Number of participants: 4
Acronym: ECsafeSEAFOOD
Project ID: 31180
Project participant:
Granby, Kit (Intern)
Sloth, Jens Jørgen (Intern)
Larsen, Bodil Katrine (Intern)
Rasmussen, Rie Romme (Intern)

Relations
Activities:
Effects of industrial processing on regulated and emerging contaminant levels in seafood
Arsenic compounds in foodstuffs –recent developments in speciation analysis and food safety assessment

Priority environmental contaminants in seafood: Safety assessment, impact and public perception (ECsafeSEAFOOD) (39039)
Seafood has been recognized as a high-quality, healthy and safe food type and is one of the most important food commodities consumed worldwide. However, seafood, like other types of food, can also be a source of harmful environmental contaminants with potential to impact on human health.

The research objectives of ECsafeSEAFOOD have been formulated from the research questions addressed in the specific objectives of the European research programme topic on building a Knowledge-Based Bio-Economy (KBBE.2012.2.4-01: Contaminants in seafood and their impact on public health (The Ocean of Tomorrow)). This topic aims to assess food safety issues related to priority contaminants present in seafood as a result of environmental contamination, including those originating from harmful algal blooms and those associated with marine litter and evaluate their impact on public health. ECsafeSEAFOOD will provide scientific evidence to serve as a basis for further development of common food safety, public health and environmental policies and measures, by seeking to establish a quantitative link between the contamination of the marine environment and that of seafood.

The specific objectives of the ECsafeSEAFOOD project include:
- Monitor the presence of priority environmental contaminants in the environment and seafood and prioritise those that are real hazards for human health.
- Quantify the transfer of relevant priority environmental contaminants between the environment and seafood, taking into account the effect of climate change.
- Study the effect of processing/cooking on the behaviour of priority contaminants in seafood.
- Understand the public health impacts of these chemical hazards, through toxicological characterisation in realistic conditions.
- Perform risk assessment to measure the potential impact of seafood contaminants on public health, using in-depth probabilistic exposure tools.
- Develop mitigation measures for risk managers, such as an online tool for different stakeholders, guidelines, phycoremediation (the use of algae to remove pollutants) and processing.
- Develop, validate and provide new, easy and fast tools to assess the presence of environmental contaminants in seafood.
- Confirm/refine the European Maximum Reference Levels in seafood for contaminants that are real hazards and for which no legislation exists or information is still insufficient.

DTU Aqua participates in the project by performing feeding trials using contaminated feed for Atlantic salmon and seabass respectively. Furthermore, the project also investigates potential effects of microplastic incorporated into feed pellets, on accumulation and elimination of the selected priority contaminants. The feeding trials consist of a 12 week to 15 week accumulation period for seabass and salmon respectively and a 8 week depuration period where all groups are fed control feed. The results obtained from the trial will be the used to develop mathematical models estimating accumulation and elimination of priority contaminants in filet.

The project is coordinated by Portuguese Institute of Sea and Atmosphere (IPMA), Portugal.

This project is funded by EU, Framework Programme 7.

National Institute of Aquatic Resources
Section for Aquaculture
National Food Institute
Portuguese Institute for the Sea and Atmosphere
AZTI-Tecnalia
University of Maribor
Ghent University
National Veterinary Institute
Catalan Institute for Water Research
Institute for Agricultural and Fisheries Research
University of Porto
Institute of Research and Technology in Food and Agriculture
Hortimare Projects & Consultancy BV
Wageningen IMARES
TecnaTox. "Rovira i Virgili" University
Aeiforia Srl
AquaTT
Agency for Marine Research and Valorisation
Polyintell
Dan Salmon
Period: 15/02/2013 → 15/02/2017
Number of participants: 3
Research area: Aquaculture
Project participant:
Larsen, Ole Madvig (Intern)
Jensen, Rasmus Frydenlund (Intern)
Development of sustainable technologies and modeling tools in aquaculture aiming at increasing overall production (UDTÆNK) (39030)
The project aimed at developing methods and modeling tools that may assist the aquaculture industry in expanding its production while minimizing the environmental impact.

To obtain this, the project included six work packages concerning:
- Increased production of rainbow trout by providing methods for reducing the discharge of nitrogen and organic matter.
- Increased production in net cages by providing academic guidance to social workers on concurrent production of trout and mussels.
- Improved sustainability of the industry by providing guidance on optimal system design with respect to reducing nutrient discharge.

The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).

National Institute of Aquatic Resources
Section for Aquaculture
Dansk Akvakultur
Period: 09/07/2012 → 31/05/2015
Number of participants: 6
Research area: Aquaculture
Project participant:
Pedersen, Per Bovbjerg (Intern)
Larsen, Bodil Katrine (Intern)
Steenfeldt, Svend Jørgen (Intern)
Phd Student:
von Ahnen, Mathis (Intern)
Letelier-Gordo, Carlos Octavio (Intern)
Project Coordinator:
Dalsgaard, Anne Johanne Tang (Intern)

HPLC and amino acids uptake patterns in fish fed plant-based protein (38803)
One of the issues of the rapidly growing aquaculture sector is to find fish meal substitutes. The main focus has been on plant proteins as a substitute for fish meal in the diet formulation. However, significant incorporation of plant proteins in the fish diet often results in reduced growth and/or impaired feed efficiency. Recent trials performed at our lab have shown that the profile of amino acid uptake (timeline) varies between rainbow trout fed plant based diet and fish meal diet. This difference in amino acid availability might well influence the protein synthesis and could add to the explanation of reduced performance of fish fed plant based diets and also the observed increased ammonia excretion.

Following these initial observations made in 2011 the project will perform a series of experiments to further examine how and why amino acid uptake patterns differ. Correlations between amino acid profile in the diet and amino acid in the blood following feeding will be made for different plant protein sources and added crystalline amino acids.

The concomitant effects on liver enzyme activity and protein synthesis will be examined and relevant indicators for protein synthesis (i.e. growth) hopefully determined. Specific digestibility and nitrogen excretion studies as well as traditional growth studies will be performed to support the findings.

The project is coordinated by DTU Aqua.

National Institute of Aquatic Resources
Section for Aquaculture
BioMar A/S
Period: 01/01/2011 → 31/12/2015
Number of participants: 5
Research area: Aquaculture
Project participant:
Skov, Peter Vilhelm (Intern)
Local raw materials for production of fish feed for aquaculture (38840)

The aquaculture industry is the fastest growing food production industry in the world and approximately 50% of all fish consumed by humans comes from aquaculture. The main cost factor in aquaculture is the cost of feed. Furthermore, high amounts of feed ingredients from marine sources have been of concern both environmentally and economically. Thus, it is of importance for the aquaculture industry to aim for the development of new locally-produced, cost-effective, beneficial and eco-friendly ingredients for innovative practical feed production. Food production, not least in the marine sector and aquaculture, is one of the main fundamental industries in the Nordic countries. Wild fisheries have stagnated or even declined and the aquaculture in other continents has been increasing substantially. It is therefore essential for these industries to implement innovative solutions to maintain the competitiveness of the region in this field. New opportunities for sustainable aquaculture production are emerging providing the tools.

The main objectives of the project were to test new local raw materials for aquaculture feed and to implement those into the production chain, with the purpose to:
- Move the Nordic aquaculture industry towards a more competitive and sustainable production with focus on efficient and responsible use of local feed sources.
- Lowering carbon footprint of aquaculture production
- Identify novel fish feed ingredients and optimizing use of marine raw materials
- Create added-value of feed sources like seaweed, microalgae and mussel meal.
- Decrease dependency of fish meal and fish oil as fish feed ingredients
- Establish a user driven diversified “green growth” aquaculture production of high quality fish products.

The specific role of DTU Aqua in the project was to evaluate mussel meal as a protein source in fish feed. For this purpose a series of digestibility and growth trials at different inclusion levels of mussel meal, with fishmeal based diets as reference, were successfully performed. DTU Aqua also examined potential environmental effects (nitrogen excretion) of replacing fishmeal with mussel meal. Furthermore, the trials provided tissue and blood-samples for closer examination of physiological effects of mussel meal on gut epithelia as well as effects on various hormones. The latter was performed by partners from University of Gothenburg.

The project was coordinated by Islensk Matorka ehf, Iceland.

The project was funded by Nordforsk, Nordic Council of Ministers.

National Institute of Aquatic Resources
Section for Aquaculture
Islensk Matorka ehf
University of Gothenburg

University of Nordland
Period: 01/01/2011 → 31/08/2014
Number of participants: 1
Research area: Aquaculture
Project participant:
Larsen, Bodil Katrine (Intern)

Strategies to improve health and welfare in rainbow trout farming (38193)

The main aim of the project is the developing of sustainable strategies for improving the health, welfare and quality of cultured rainbow trout by implementing three interrelated approaches: management, immune prophylactics, and selective breeding. The management approach determines how increased water current at given rearing densities and water temperatures can reduce the stress of trout. The immune prophylactic approach determines the relationship between immune response profiles and induction of protective immunity at different water temperatures and hereby establishing efficient strategies for use of vaccination and feed stimulants in prevention of diseases. The selective breeding approach determines how physiological and immunological traits can improve the genetically basis for resistance of trout to stress and disease.

The project is coordinated by DTU Aqua.
National Veterinary Institute
National Institute of Aquatic Resources
Section for Aquaculture
University of Copenhagen

Aarhus University
Period: 01/01/2007 → 31/12/2010
Number of participants: 5
Research area: Aquaculture
Project participant:
Höglund, Erik (Intern)
Larsen, Bodil Katrine (Intern)
Skov, Peter Vilhelm (Intern)
McKenzie, David D. (Ekstern)
Project Manager, organisational:
Jokumsen, Alfred (Intern)

Project