Ozonation control and effects of ozone on water quality in recirculating aquaculture systems

To address the undesired effect of chemotherapeutants in aquaculture, ozone has been suggested as an alternative to improve water quality. To ensure safe and robust treatment, it is vital to define the ozone demand and ozone kinetics of the specific water matrix to avoid ozone overdose. Different ozone dosages were applied to water in freshwater recirculating aquaculture systems (RAS). Experiments were performed to investigate ozone kinetics and demand, and to evaluate the effects on the water quality, particularly in relation to fluorescent organic matter. This study aimed at predicting a suitable ozone dosage for water treatment based on daily ozone demand via laboratory studies. These ozone dosages will be eventually applied and maintained at these levels in pilot-scale RAS to verify predictions. Selected water quality parameters were measured, including natural fluorescence and organic compound concentration changes during ozonation. Ozone reactions were described by first order kinetics. Organic matter, assessed as chemical oxygen demand and fluorescence, decreased by 25% (low O3), 30% (middle O3) and 53% (high O3), while water transmittance improved by 15% over an 8-day period. No fish mortality was observed. Overall, this study confirms that ozone can improve RAS water quality, provides a better understanding of the ozone decay mechanisms that can be used to define further safe ozone treatment margins, and that fluorescence could be used as a monitoring tool to control ozone. This study might be used as a tool to design ozone systems for full-scale RAS by analysing water sample from the specific RAS in the laboratory.

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Bacterial activity dynamics in the water phase during start-up of recirculating aquaculture systems

Microbial water quality in recirculating aquaculture systems (RAS) is important for successful RAS operation but difficult to assess and control. There is a need to identify factors affecting changes in the bacterial dynamics – in terms of abundance and activity – to get the information needed to manage microbial stability in RAS. This study aimed to quantify bacterial activity in the water phase in six identical, pilot scale freshwater RAS stocked with rainbow trout (Oncorhynchus mykiss) during a three months period from start-up. Bacterial activity and dynamics were investigated by the use of a patented method, BactiQuant®. The method relies on the hydrolysis of a fluorescent enzyme-substrate and is a rapid technique for quantifying bacterial enzyme activity in a water sample. The results showed a forty-fold increase in bacterial activity within the first 24 days from start-up. Average BactiQuant® values (BQV) were below 1000 at Day0 and stabilized around 40,000 BQV after four weeks from start. The study revealed considerable variation in initial BQV levels between identically operated and designed RAS; over time these differences diminished. Total ammonia nitrogen, nitrite and nitrate levels were very similar in all six RAS and were neither related to nor affected by BQV. Chemical oxygen demand (COD) and biological oxygen demand (BOD5) were highly reproducible parameters between RAS with a stable
equilibrium dynamic over time. This study showed that bacterial activity was not a straightforward predictable parameter in the waterphase as e.g. nitrate-N would be in identical RAS, and showed unexpected sudden changes/fluctuations within specific RAS. However, a bacterial activity stabilization phase was observed as systems matured and reached equilibrium, suggesting a successive transition from fragile to robust microbial community compositions.

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Web of Science (2006): Indexed yes
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Crosstalk between innate immunity and circadian rhythm: Do fish immune defences have a sense of time?

First experiences from full-scale denitrifying woodchip bioreactors operated end-of-pipe at commercial RAS

Influence of fixed and moving bed biofilters on micro particle dynamics in a recirculating aquaculture system
particles/mL) per passage through FBB, and increased by 252 particles (from 2409 to 2667 particles/mL) per passage through MBB. In FBB, a 10% reduction in particle concentration also represented a 10% reduction in total particle surface area and particle volume. In MBB, a 10% increase in particle concentration also represented a 10% increase in total particlesurface area, but had no effect on total particle volume. A volumetric reduction of particles >100 μm, and an equivalent volumetric increase of particles <40 μm, showed that MBB produced fine particles by disintegration of larger particles. A constant removal of particulate volume through all size classes by FBB demonstrates their function as secondary particle removal units. Net removal of organic matter (Concentration IN − Concentration OUT), as biochemical oxygen demand after 5 days (BOD5), occurred at the same rates in both modes of operation. While FBB removed a higher amount of filtered BOD5 (material filtered through a 1.6 m filter) than MBB, MBB removed more particulate BOD5 (Particulate = Raw − Filtered) than FBB, presumably due to disintegration of particles in MBB. In the RAS, ammonia and nitrite were observed at concentrations below 0.2 mg N/L throughout the majority of the experiment. However, during the phase where only MBB were in operation, TAN (Total Ammonia Nitrogen) and nitrite levels increased significantly. Nitrate levels ranged between 40 and 44 mg N/L, reflecting stable operating conditions and constant feed loading. The trends observed when FBB or MBB were operated separately were also observed when all filters were operated simultaneously. Differences in biofilm formation, development and maintenance, coupled to reactor flow characteristics are discussed in relation to the fate of micro particles and organic matter when operating fixed or moving bed biofilters in RAS.
Micro particles in Danish Model Trout Farms

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Monitoring abrupt changes in bacteria within biological stable RAS water

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Optimum ozonation of freshwater pilot recirculating aquaculture system - Water quality

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Particle surface area and bacterial activity in recirculating aquaculture systems
Suspended particles in recirculating aquaculture systems (RAS) provide surface area that can be colonized by bacteria. More particles accumulate as the intensity of recirculation increases thus potentially increasing the bacterial carrying capacity of the systems. Applying a recent, rapid, culture-independent fluorometric detection method (Bactiquant®) for measuring bacterial activity, the current study explored the relationship between total particle surface area (TSA, derived from the size distribution of particles >5 μm) and bacterial activity in freshwater RAS operated at increasing intensity of recirculation (feed loading from 0.043 to 3.13 kg feed m−3 make-up water). Four independent sets of water samples from different systems were analyzed and compared including samples from: (i) two individual constructed wetlands treating the effluent system water from two commercial, freshwater rainbow trout (Oncorhynchus mykiss) farms of different recirculation intensity; (ii) an 8.5 m3 pilot scale RAS; and (iii) twelve identical, 1.7 m3 pilot scale RAS assigned one of four micro-screen treatments (no micro-screen, 100, 60, or 20 μm mesh size micro-screens) in triplicate. There was a strong, positive, linear correlation (p < 0.05) between TSA and bacterial activity in all systems with low to moderate recirculation intensity (i.e. feed loading ≤1 kg feed m−3 make-up water). However, the relationship apparently ceased to exist in the
systems with highest recirculation intensity (feed loading 3.13 kg feed m⁻³ make-up water; corresponding to 0.32 m³ make-up water kg⁻¹ feed). This was likely due to the accumulation of dissolved nutrients sustaining free-living bacterial populations, and/or accumulation of suspended colloids and fine particles less than 5 μm in diameter, which were not characterized in the study but may provide significant surface area. Hence, the study substantiates that particles in RAS provide surface area supporting bacterial activity, and that particles play a key role in controlling the bacterial carrying capacity at least in less intensive RAS. Applying fast, culture-independent techniques for determining bacterial activity might provide a means for future monitoring and assessment of microbial water quality in aquaculture farming systems.

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Rhythmicity and plasticity of digestive physiology in a euryhaline teleost fish, permit (Trachinotus falcatus)

Digestive physiology is considered to be under circadian control, but there is little evidence in teleost fish. The present study explored the rhythmicity and plasticity to feeding schedules of enzymatic digestion in a candidate aquaculture fish, the permit (Trachinotus falcatus). The first experiment identified the rhythms of digestive factors throughout the light-dark (LD) cycle. Gastric luminal pH and pepsin activity showed significant daily variation albeit not rhythmic. These dynamic changes were likewise observed in several digestive enzymes, in which the activities of intestinal protease, chymotrypsin and lipase exhibited significant daily rhythms. In the second experiment, the existence of feed anticipatory activity in the digestive factors was investigated by subjecting the fish to either periodic or random feeding. Anticipatory gastric acidification prior to feeding was identified in periodically fed fish. However, pepsin activity did not exhibit such anticipation but a substantial postprandial increase was observed. Intestinal protease, leucine aminopeptidase and lipase anticipated periodic mealtime with elevated enzymatic activities. Plasma melatonin and cortisol demonstrated robust daily rhythms but feeding time manipulations revealed no significant impact. Plasma ghrelin level remained constant during the LD cycle and appeared to be unaffected by differing feeding regimes as well. Taken together, the digestive factors of permit were highly dynamic during the LD cycle. Periodic feeding entrained digestive physiology and mediated anticipatory gastric acidification and intestinal enzymatic activities. This knowledge will be essential in developing feeding protocols and husbandry-related welfare strategies that will further advance this candidate finfish as an aquaculture species.

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BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.917 SNIP 0.915 CiteScore 2.01
Web of Science (2015): Indexed yes
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Scopus rating (2014): SJR 0.983 SNIP 0.94 CiteScore 2.18
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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 acetic 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.

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Scopus rating (2003): SJR 0.893 SNIP 1.435
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Scopus rating (2000): SJR 0.307 SNIP 0.785
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Effects of feed loading on microbial water quality in RAS

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Innate immune defenses exhibit circadian rhythmicity and differential temporal sensitivity to a bacterial endotoxin in Nile tilapia (Oreochromis niloticus)

The present study investigated the daily dynamics of humoral immune defenses and the temporal influence in the sensitivity of these responses to a bacterial endotoxin in Nile tilapia (Oreochromis niloticus). The first experiment subjected the fish to two photoperiod conditions, 12L:12D (LD) and 0L:24D (DD), for 20 days to characterize the rhythms of humoral immunity. Serum alkaline phosphatase (ALP), lysozyme (LYZ), peroxidase (PER) and protease (PRO) exhibited significant rhythmicity under LD but not in DD. No significant rhythms were observed in esterase (ESA) and anti-protease (ANTI) in both photoperiod conditions. Fish reared under LD were subsequently subjected to DD while the group previously under DD was exposed to LD, and this carried on for 3 days before another set of samples was collected. Results revealed that the rhythms of LYZ, PER and PRO but not ALP persisted when photoperiod was changed from LD to DD. Nonetheless, immune parameters remained arrhythmic in the group subjected from DD to LD. Cluster analysis of the humoral immune responses under various light conditions revealed that each photic environment had distinct daily immunological profile. In the second experiment, fish were injected with bacterial endotoxin lipopolysaccharide (LPS) either at ZT3 (day) or at ZT15 (night) to evaluate the temporal sensitivity of humoral immunity to a pathogen-associated molecular pattern. The results demonstrated that responses to LPS were gated by the time of day. LPS significantly modulated serum ALP and ANTI activities but only when the endotoxin was administered at ZT3. Serum LYZ and PER were stimulated at both injection times but with differing response profiles. Modulated LYZ activity was persistent when injected at ZT3 but transient when LPS was applied at ZT15. The magnitude of LPSinduced PER activity was higher when the endotoxin was delivered at ZT3 versus ZT15. It was further shown that plasma cortisol was significantly elevated but only when LPS was administered at ZT3. On the other hand, plasma melatonin was significantly affected by LPS injection but only when exposed at ZT15. Taken together, this study shows that several key components of humoral immunity in tilapia exhibit circadian rhythms and adapt to photoperiodic changes. Further, results of the bacterial endotoxin challenge suggest that responsiveness of serum humoral factors to a biological insult is likely mediated by the time of day, highlighting the importance of circadian rhythms in the immunological functions of fish

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Microbial water quality - tools and challenges

New approaches to improve the removal of dissolved organic matter and nitrogen in aquaculture

Reducing the environmental impact of aquaculture requires that waste treatment practices are further improved. Currently applied treatment technologies achieve good solids removal and nitrification. Yet discharge of nitrogen (N) and organic matter (OM) from fish farms is still often an important issue constraining aquaculture development, especially in sensitive areas. Possibilities for efficient end-of-pipe treatment exist for large intensive recirculating aquaculture systems (RAS), while smaller and especially the technically less advanced fish farms, struggle to reduce nutrient discharge further due to the lack of cost-effective and easy applicable treatment methods for removing dissolved N and OM. The purpose of this PhD thesis was to assess the problem of removing dissolved N and OM in the context of the large differences in system intensity between farms, and to devise new, simple methods for removing dissolved N and OM from aquaculture effluents of technically less advanced farms in particular. The work split in two parts. The first part focused on the turnover of dissolved N-compounds (Paper I) and dissolved organic matter (DOM) (Paper II) and in aerobic biofilters operated at increasing long-term waste loadings. The second part examined the potential of using anoxic denitrifying woodchip bioreactors for removal of nitrate from aquaculture effluent (Paper III-V). Investigations within the first part showed that the effectiveness of biofilters, as determined by their areal removal rates, for removing DOM and degrading ammonia, nitrite and urea, increased with increasing long-term waste loading. The findings sustained/suggested? that DOM to (some extend)? can be removed by biofiltration, and that biofilters therefore may be applied for removing DOM from aquaculture effluents. The studies furthermore showed that degradation of urea contributes to the ongoing nitrification activity in aquaculture biofilters, and that the transition zone from first order (substrate dependent) to zero order (substrate independent) degradation of ammonia and nitrite was elevated with increasing long-term biofilter loading up to a certain threshold. The latter indicated that the removal capacity of biofilters operated at lower loadings is easily exceeded, and that they may not respond very well to sudden increases in total ammonia nitrogen (TAN) concentrations. In the second part of the thesis, a field study documented the start-up performance of a pilot-scale, denitrifying woodchip bioreactor at a commercial outdoor fish farm (Paper III). Nitrate removal was immediate after bioreactor start-up and was accompanied by short-term leaching of nutrients and organic matter from the woodchips. The study demonstrated that woodchip bioreactors are able to remove nitrate from dilute aquaculture effluents under commercial conditions. The obtained nitrate removal rate (7.06±0.81 g NO3-N/m3/d at ~8°C) was, however, relatively low, signifying that a quite large reactor would be required for complete removal of NO3-N at commercial farms. Laboratory studies were therefore carried out to test whether removal rates in woodchip bioreactor could be improved. Paper IV demonstrated that simultaneously changing the hydraulic retention time and adding bicarbonate to the inlet water of laboratory-scale woodchip bioreactors improved N removal. Moreover, the study indicated that sulfur-based autotrophic denitrification is potentially important to the overall N removal in woodchip bioreactors. A subsequent laboratory study demonstrated that higher N removal rates could be achieved in mixotrophic denitrification reactors containing mixtures of woodchips, sulfur granules and seashells (Paper V).

12 Altogether, the woodchip studies sustained that denitrifying woodchip bioreactors may represent an alternative and simple method for removing nitrate from dilute/low-organic-strength aquaculture effluents for which application of, for example, heterotrophic denitrification reactors needing input of organic carbon sources is generally not feasible.

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Optimizing nitrate removal in woodchip beds treating aquaculture effluents

Nitrate is typically removed from aquaculture effluents using heterotrophic denitrification reactors. Heterotrophic denitrification reactors, however, require a constant input of readily available organic carbon (C) sources which limits their application in many aquaculture systems for practical and/or economic reasons. A potential alternative technology for removing nitrate currently applied for treating surface and drainage water is based on using wood by-products as a carbon source for denitrification. Using lab-scale horizontal-flow woodchip filters, the current study investigated the potential of optimizing woodchip reactors for treating aquaculture effluent. A central composite design (CCD) was applied to assess the effects of simultaneously changing the empty bed contact time (EBCTs of 5.0-15.0 h; corresponding to theoretical hydraulic retention times of 3.3-9.9 h) and bicarbonate (HCO3⁻) inlet concentration (0.50-1.59 g HCO3⁻/l) on the removal rate of NO3⁻-N, and additional organic and inorganic nutrients, in effluent deriving from an experimental recirculating aquaculture system (RAS). Volumetric NO3⁻-N removal rates ranged from 5.20 ± 0.02 to 8.96 ± 0.19 g/m3/day and were enhanced by adding bicarbonate, suggesting that parts of the removal was due to autotrophic denitrification. The highest N removal rate (8.96 ± 0.05 g/m3/day) was achieved at an EBCT and HCO3⁻ combination of 15 h and 1.59 g HCO3⁻/l. Bicarbonate inlet concentration as a single factor had the strongest effect on N removal rates followed by the interaction with EBCT, and EBCT² (quadratic term). The study thus indicates that woodchip beds may be applied and optimized for removing nitrate from aquaculture effluents. Statement of relevance: This study is a relevant contribution to research in aquaculture as it presents an alternative method for removing nitrates from aquaculture effluents especially for less intensive fish farms. Furthermore, it shows how this method can be optimized to yield higher removal rates of nitrate.
Start-up performance of a woodchip bioreactor operated end-of-pipe at a commercial fish farm—A case study

There is a need for simple, maintenance-free technologies for removing nitrogen (N) from aquaculture effluents. Denitrifying woodchip bioreactors have been used successfully to remove nitrate-N (NO₃-N) from ground and surface waters and may potentially be applied to dilute aquaculture effluents as well. Real-life applicability in commercial, outdoor fish farms including practical start-up issues such as e.g. time till stable performance and potential leaching are, however, unknown to the industry. This case study consequently investigated the temporal performance of a woodchip bioreactor (12.5 m³) during start-up. The bioreactor was operated end-of-pipe at a commercial, outdoor rainbow trout (Oncorhynchus mykiss) farm in Denmark operated at low recirculation intensity. Applying an empty bed contact time (EBCT) of 5 h, the specific objectives of the study were to resolve: i) how fast the bioreactor would start to remove NO₃-N; ii) how fast steady state was achieved; iii) which NO₃-N removal rates could be attained at the relatively low effluent temperature (∼8 °C) and iv) to which extent any concomitant leaching of phosphorous (P), ammonia or organic matter would occur. In- and outlet grab samples were obtained every 6 h until the bioreactor was in steady state (2 weeks) followed by weekly 24 h pooled samples for another 3 weeks (5 weeks in total). Additional grab samples were obtained from 9 sampling ports within the bioreactor on 3 consecutive days during steady state. Samples were analyzed for dissolved nutrients (total N, nitrate, nitrite, ammonia, total phosphorous, ortho-phosphorous, BOD₅ and COD). In addition, oxygen, temperature and pH were logged every 30 min while sampling and alkalinity were measured once a week. Removal of NO₃-N started immediately and remained stable at 7.06 ± 0.81 g NO₃-N/m³/d (n = 6) throughout the sampling period. Increased effluent NO₂-N concentrations (peaking at 1.14 mg NO₂-N/l after 4–5 days) were transiently observed during the initial 11 days. After that, the woodchip bioreactor was largely in steady state with respect to N-balances corroborated by a close match between filtered total-N (TNdiss) and NO₃-N removal rates. Measurements within the bed showed that the majority of the influent dissolved oxygen (DO) was consumed within the first part of the bioreactor and that NO₃-N removal thereafter proceeded gradually with distance within the bed. Leaching of non-structural, dissolved organic compounds were observed just after startup, causing a short-term (1 week) increase in effluent concentrations of COD, BOD₅, P and ammonium. Additional measurements carried out until 147 days after start-up showed that the woodchip bioreactor continued to remove TNdiss at an average removal rate of 7.81 ± 0.82 g N/m³/d, and that the initial leakage of P stopped altogether. In summary, the study demonstrated that woodchip bioreactors can effectively remove NO₃-N from dilute aquacultural effluents at low temperatures and commercial conditions and that stable performance is achieved within a few weeks.
Supplementing enzymes to extruded, soybean based diet improves breakdown of non-starch polysaccharides in rainbow trout (Oncorhynchus mykiss)

Plant-based feed ingredients typically contain remnants of dietary fibres [DF; non-starch polysaccharides (NSP) and lignin] that have various antinutritive effects in carnivorous fish. Exogenous enzymes have been shown to improve the apparent digestibility coefficients (ADC) of plant-based diets presumably by assisting in the breakdown of NSP. This study examined the effects on NSP degradation when supplementing β-glucanase, xylanase, protease or a mix of the three enzymes to an extruded, juvenile rainbow trout (Oncorhynchus mykiss) diet containing 344 g kg⁻¹ de-hulled, solvent-extracted soybean meal (SBM). The NSP content in the non-supplemented control diet and in faecal samples from the dietary treatment groups was analysed to determine the recovery/apparent digestibility of cellulose and total non-cellulosic polysaccharides (T-NCP) sugar monomers. The enzymes had significant, positive effects at the pH range and temperature prevailing in the gastrointestinal tract: β-glucanase improved the ADC of mannose, galactose and uronic acids; xylanase and protease improved the ADC of xylose; and protease furthermore improved the ADC of mannose and uronic acids. There were no effects when supplementing all three enzymes together. In conclusion, exogenous enzymes may potentially be applied to fish feed containing SBM, assisting in the breakdown of NSP and alleviating some of the antinutritive effects
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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Biofilter effects on micro particle dynamics

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Characterising organic matter in recirculating aquaculture systems with fluorescence EEM spectroscopy
The potential of recirculating aquaculture systems (RAS) in the aquaculture industry is increasingly being acknowledged. Along with intensified application, the need to better characterise and understand the accumulated dissolved organic matter (DOM) within these systems increases. Mature RASs, stocked with rainbow trout and operated at steady state at four feed loadings, were analysed by dissolved organic carbon (DOC) analysis and fluorescence excitation-emission matrix (EEM) spectroscopy. The fluorescence dataset was then decomposed by PARAFAC analysis using the drEEM toolbox. This revealed that the fluorescence character of the RAS water could be represented by five components, of which four have previously been identified in fresh water, coastal marine water, wetlands and drinking water. The fluorescence components as well as the DOC showed positive correlations with feed loading, however there was considerable variation between the five fluorescence components with respect to the degree of accumulation with feed loading. The five components were found to originate from three sources: the feed; the influent tap water (groundwater); and processes related to the fish and the water treatment system. This paper details the first application of fluorescence EEM spectroscopy to assess DOM in RAS, and highlights the potential applications of this technique within future RAS.
Degradation of urea, ammonia and nitrite in moving bed biofilters operated at different feed loadings

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End-of-pipe removal of nitrogen using woodchip beds

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Feed composition affects sludge as a resource for denitrification

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Humoral and mucosal defense molecules rhythmically oscillate during a light–dark cycle in permit, Trachinotus falcatus

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Interactions between micro-particles and the rearing environment in recirculation aquaculture systems

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Microbial water quality dynamics in RAS during system start-up

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Organisations: National Institute of Aquatic Resources, Section for Aquaculture
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Microscreen effects on water quality in replicated recirculating aquaculture systems

This study investigated the effects of three microscreen mesh sizes (100, 60 and 20 μm) on water quality and rainbow trout (Oncorhynchus mykiss) performance compared to a control group without microscreens, in triplicated recirculating aquaculture systems (RAS). Operational conditions were kept constant during a 6-week period where the microscreens were manually rinsed three times a day. The effects of microscreen cleaning frequency and nitrification performance were subsequently assessed.

Compared to the control group, microscreens removed particles, reduced particulate organic matter, and increased β-values. Particulate parameters reached steady-state in all treatment groups having microscreens at the end of the trial. The time to reach equilibrium seemingly increased with increasing mesh size but the three treatment groups (100, 60 and 20 μm) did not significantly differ at the end of the trial. Increased backwashing frequency over a 24-h period had no further significant effects on the parameters measured. The results demonstrated the role and importance of a microscreen, and showed that mesh size, within the range tested, is less important at long operations under constant conditions.

Fish performed similarly in all treatments. Preliminary screening of trout gills did not reveal any pathological changes related to microscreen filtration and the resulting water quality. Biofilter performance was also unaffected, with 0'-order nitrification rates (k0a) being equivalent for all twelve systems (0.148 ± 0.022 g N m⁻² d⁻¹).

Mechanisms for RAS equilibrium establishment, within and between systems with different mesh sizes, are discussed.
Monitoring RAS organic matter by fluorescence EEM spectroscopy

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Nitrification performance and robustness of fixed and moving bed biofilters having identical carrier elements
This study compared moving bed (MB) and fixed bed (FB) biofilter performance. The experimental recirculating aquaculture system had four equal biofilters in parallel. Each of the two replicated FB biofilters(with heavy elements) and
the two MB biofilters (with neutral elements) had 200 l carrier media with a surface specific area to volume ratio of 750 m2/m3. Total ammonia nitrogen (TAN) and apparent nitrite removal rates were measured during identical steady-state conditions and during a water treatment event where 50 mg/l hydrogen peroxide was applied. FB biofilters were found to perform equal to or better than MB biofilters during the experimental phases. The average (n = 2) surface specific TAN removal in the FB biofilters was significantly higher than the MB biofilters (0.20 vs. 0.14; g N/m2/d) at steady state. The FB biofilters had a positive apparent nitrite removal (0.02 g N/m2/d) at steady state in contrast to MB biofilters releasing nitrite (~0.02 g N/m2/d). Application of H2O2 caused a transient five-fold TAN increase up to 1.05 mg N/l in the system. Prolonged elevated nitrite levels up to 2.85 mg N/l (>15 fold increase) was observed for one week due to reduced nitrite oxidation particularly in the MB biofilters. The findings indicate FB biofilters to be more resistant against the sanitizer applied, due to increased organic matter in the biofilters compared to MB biofilters. Aspects of the experimental setup are discussed in relation to other studies and commercial biofilter operations.

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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.

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Reducing the dietary protein: Energy (P: E) ratio changes solubilization and fermentation of rainbow trout (Oncorhynchus mykiss) faeces

Nutrients discharged from aquaculture industries can detrimentally affect water recipients, and this problem must be addressed if the production is to be decoupled from the natural environment. Denitrification is a process by which nitrate is removed using soluble, readily biodegradable carbon compounds. Hydrolysis and concomitant fermentation of organic solids produces such soluble carbon compounds e.g. in the form of volatile fatty acids (VFAs). The current study examined the hydrolysis and the production of VFAs, the carbon:nitrogen ratio (C:N), and the release of nutrients (phosphorus and ammonium) from hydrolyzing and fermenting settable faecal solids (SFS) obtained from rainbow trout (Oncorhynchus mykiss). Triplicate tanks of fish were fed five isoenergetic experimental diets with different protein:energy (P:E) ratios: 15,
The SFS from four consecutive days were collected and pooled prior to incubation in 15, 1L anoxic/anaerobic batch reactors maintained at 20±2°C and continuous magnetic stirring. Daily samples from the batch reactors were obtained for 7 successive days and analyzed for total ammonia nitrogen (TAN), phosphorus expressed as orthophosphate (PO43--P), VFA, and soluble COD (sCOD). The results showed that the two lowest P:E ratio diets (i.e. 15 and 17) produced SFS with a significantly higher degree of solubilization measured as sCOD:total chemical oxygen demand (TCOD), compared to the higher P:E ratio diet 21 (0.30-0.29 versus 0.24g sCOD/g TCOD). Inversely, SFS deriving from the lowest P:E ratio diet (i.e. 15) displayed the lowest degree of fermentation measured as VFAs/sCOD, compared to SFS deriving from the four higher P:E diets (0.36 versus 0.51-0.56g VFA/g sCOD). In the same way, the lowest P:E diet showed a significantly lower solubilization of nitrogen measured as TAN:total Kjeldahl Nitrogen (TKN) compared to the three highest P:E diets (i.e. 19-23; 0.14 versus 0.26-0.34g TAN/g TKN). The two lowest P:E diets (i.e. 15-17) showed on the contrary the highest solubilization of phosphorus expressed as PO43--P:total phosphorus (TP) (0.15 and 0.08g/g, respectively) probably due to the lower pH obtained. All SFS produced enough soluble carbon, measured as VFAs, to stoichiometrically denitrify the nitrogen (N) contained in the faeces and potentially additionally 86-100% of all N produced from the fish culture process.

**General Information**

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Organisations: National Institute of Aquatic Resources, Section for Aquaculture, BioMar A/S
Authors: Letelier-Gordo, C. O. (Intern), Dalsgaard, A. J. T. (Intern), Suhr, K. I. (Intern), Pedersen, P. B. (Intern), Ekmann, K. S. (Ekstern)
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ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
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Room for all? - particulate surface area and bacterial activity in RAS

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Organisations: National Institute of Aquatic Resources, Section for Aquaculture, Christian-Albrechts-Universität zu Kiel
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Publisher: Technical University of Denmark. National Institute of Aquatic Resources
Editor: Anne Johanne Tang, D.

Series: DTU Aqua Report
Number: 301-2015
ISSN: 1395-8216
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Workshop: 3rd NordicRAS Workshop on Recirculating Aquaculture Systems, Molde, Norway, 30/09/2015 - 30/09/2015
Electronic versions:

Daily micro particle distribution of an experimental recirculating aquaculture system – A case study
The particle size distribution (PSD) in a recirculating aquaculture system (RAS) was investigated during a 24-h cycle. PSD was analyzed in water sampled at several locations in a recirculation loop containing a 60-m drum filter, a submerged fixed-bed biofilter and a trickling filter. In relation to total counts, the system was dominated by micro-particles with particles smaller than 20 m comprising >94% of the distribution in all samples. However, the system presented a substantial volumetric influence of larger particles, reflected by a PSD derive “value of 3.40 ± 0.18. Overall “value throughout the compartments (p = 0.584) and experimental period (p = 0.217) were not significantly different, although specific components seemed to marginally affect the PSD. A high internal water turnover rate (one system passage every 50 min) promoted the rapid removal of large particles from the system. Permanent volumetric particle removal above 60 m (31% reduction in the relative contribution from each size by the drum filter) per passage, but marginal production and removal of particles throughout the rest of the system further support the “value stability and consequential PSD equilibrium. The results showed a stable “value in the mature RAS. The “value is influenced by the...
contained compartments and system configuration, and may be used as a system performance-predicting tool. Mechanisms of particle influence on system and fish performance should be addressed in future studies, and are herein discussed.

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Organisations: National Institute of Aquatic Resources, Section for Aquaculture
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Scopus rating (2011): SJR 0.69 SNIP 1.406 CiteScore 1.54
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Scopus rating (2009): SJR 0.717 SNIP 1.424
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Scopus rating (2008): SJR 0.734 SNIP 1.154
Scopus rating (2007): SJR 0.699 SNIP 1.088
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.629 SNIP 1.191
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.615 SNIP 1.123
Scopus rating (2004): SJR 0.547 SNIP 1.204
Scopus rating (2003): SJR 0.893 SNIP 1.435
Scopus rating (2002): SJR 0.344 SNIP 0.737
Effects of dietary protein: energy ratios on hydrolysis and fermentation of faecal solids from rainbow trout (Oncorhynchus mykiss) for denitrification

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Organisations: National Institute of Aquatic Resources, Section for Aquaculture
Authors: Letelier-Gordo, C. O. (Intern), Dalsgaard, A. J. T. (Intern), Suhr, K. I. (Intern), Pedersen, P. B. (Intern)
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Ozone in a jar: water treatment with peracetic acid products

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Organisations: National Institute of Aquatic Resources, Section for Aquaculture, Danish Aquaculture Organisation
Authors: Pedersen, L. (Intern), Henriksen, N. (Ekstern), Pedersen, P. B. (Intern)
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Removal of urea, ammonium and nitrite in moving bed biofilters operated at different loadings

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Publication date: 2014
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Water quality in an experimental Recirculating Aquaculture System as affected by biofilter mode of operation

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Biofilter-specific responses to intense water treatment in RAS

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Organisations: National Institute of Aquatic Resources, Section for Aquaculture
Authors: Pedersen, L. (Intern), Oosterveld, R. (Intern), Pedersen, P. B. (Intern)
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Drifts- og miljømæssig optimering af recirkulerede opdrætsanlæg

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Publication: Research › Report – Annual report year: 2013

End-of-pipe denitrification using RAS effluent waste streams: Effect of C/N-ratio and hydraulic retention time

Environmentally sustainable aquaculture development requires increased nitrogen removal from recirculating aquaculture systems (RAS). In this study, removed solids from a large commercial outdoor recirculated trout farm (1000 MT year−1) were explored as an endogenous carbon source for denitrification. This was done by (1) a controlled laboratory experiment on anaerobic hydrolysis of the organic matter (from sludge cones, drumfilter, and biofilter back-wash) and (2) an on-site denitrification factorial experiment varying the soluble COD (CODS)/NO3-N ratio from 4 to 12 at hydraulic retention times (HRT) from 50 to 170 min in simple 5.5 m3 denitrification reactors installed at the trout farm. The lab-experiments showed that the major part of the readily biodegradable organic matter was hydrolyzed within 14 days, and the hydrolysis rate was fastest the first 24 h. Organic matter from the sludge cones generated 0.21 ± 0.01 g volatile fatty acids (VFA) g−1 total volatile solids (TVS), and the VFAs constituted 75% of CODS. Analogously, 1 g TVS from the drum filter generated 0.15 ± 0.01 g VFA, constituting 68% of the CODS. Comparison of the laboratory hydrolysis experiments and results from the on-farm study revealed as a rough estimate that potentially 17–24% of the generated VFA was lost due to the current sludge management. Inlet water to the denitrification reactors ranged in NO3-N concentration from 8.3 to 11.7 g m−3 and CODS from 52.9 to 113.4 g m−3 (10.0 ± 1.2 °C). The highest NO3-N removal rate obtained was at the intermediate treatments; 91.5–124.8 g N m−3 reactor d−1. The effect of the C/N ratio depended on the HRT. At low HRT, the variation in C/N ratio had no significant effect on NO3-N removal rate, contrary to the effect at the high HRT. The stoichiometric ratio of CODS/NO3-N was 6.0 ± 2.4, ranging from 4.4 (at the high HRT) to 9.3 (at the low HRT). A simple model of the denitrification reactor developed in AQUASIM showed congruence between modeled and measured data with minor exceptions. Furthermore, this study pointed to the versatility of the NO3-N removal pathways expressed by the bacterial population in response to changes in the environmental conditions; from autotrophic anammox activity presumably present at low C/N to dissimilatory nitrate reduction to ammonia (DNRA) at high C/N, besides the predominate “normal” heterotrophic dissimilatory nitrate reduction (denitrification)

General information
Farming different species in RAS in Nordic countries: Current status and future perspectives

Recirculating aquaculture systems (RAS) have gained increasing interest in recent years as a means to intensify fish production while at the same time minimize the environmental impact. Considerable hands-on experience has accumulated within the Nordic countries over the last 20-30 years in designing, building, and operating intensive land-based RAS for different species. This study compiles and assesses published literature along with un-published hands-on experiences with rearing different species in RAS in the Nordic countries, including Atlantic salmon (Salmo salar), rainbow trout (Oncorhynchus mykiss), European eel (Anguilla anguilla), pike perch (Stizostedion lucioperca), Arctic char (Salvelinus alpinus), sturgeon (order Acipenseriformes), Nile tilapia (Oreochromis niloticus), and European lobster (Homarus gammarus). High capital costs are one of the biggest challenges to sustainable RAS calling for large scale intensive productions to reduce investment -and operation costs. Consistent with this, production of Atlantic salmon smolts in indoor RAS and rainbow trout in outdoor Model-Trout-Farms (MTFs) have been the commercially most successful productions so far. Aside from end-of-pipe treatment including sludge handling and efficient nitrogen removal, much of the RAS technology applied is well known and is, as such, more or less ready to apply for culturing a variety of species. Successful production of “new” species in RAS therefore largely comes down to identifying the biological requirements of that specific species, and designing the RAS to fulfill and support the specific requirements. Well established brood-stocks and continuous supply of offspring is furthermore a prerequisite for successful RAS production of most species. Successful operations of less intensive RAS such as aquaponic systems appear to be feasible primarily when culturing more exotic species targeted for selected customers.

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Authors: Dalsgaard, A. J. T. (Intern), Lund, I. (Intern), Thorarinsdottir, R. (Ekstern), Drengstig, A. (Ekstern), Arvonen, K. (Ekstern), Pedersen, P. B. (Intern)
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Feed intake as explanation for density related growth differences of common sole Solea solea

Growth of common sole Solea solea is negatively correlated to density, which affects productivity in culture and hence commercial success. Studies of individual feed intake were performed to examine growth and population dynamics at different densities. Three initial stocking densities: 1.0, 2.1 and 3.9 kg m⁻² of individually tagged sole, referred to as low density (LD), medium density and high density HD), were examined during 145 days. Despite that tank productivity (g m⁻² day⁻¹), was highest for the HD group, the specific growth rate (SGR) decreased significantly with increase in stocking density. Individual size variation was similar between densities, indicating that growth was not associated with hierarchy and dominant behaviour. Individual data indicated that increased density reduced the growth potential of all individuals in a population. Individual feed intake was positively correlated to both fish size and individual SGR. Feed conversion ratio was likewise positively correlated to feed intake. The relative feed intake (g feed g fish⁻¹) was not correlated to fish size at any density tested, but was significantly highest for the LD population. This explains a substantial part of the better growth in the LD group supported by indications of better utilization of the ingested feed.
Hypercapnia adversely affects postprandial metabolism in the European eel (Anguilla anguilla)

The present study examined the effects of elevated CO2 partial pressure on the specific dynamic action (SDA) and ammonia excretion in European eel (Anguilla anguilla) following forced feeding. Two different hypercapnic scenarios were investigated; one in which pCO2 oscillated between 20 and 60 mm Hg over 24 hour cycles, and one in which pCO2
was constant at 60 mm Hg. Since high CO2 results in low pH with unchanged alkalinity, a normocapnic group at low pH (pCO2 = 3 mm Hg, pH = 6.5) was included to investigate possible direct effects of pH. Constant hypercapnia (60 mm Hg) and low pH (pH = 6.5) both significantly increased the duration of the SDA response by 22% and 29%, respectively. Hypercapnia had no effect on standard metabolic rate, while constant or oscillating hypercapnia significantly lowered the maximum metabolic rate compared to controls, causing a significant reduction of the aerobic scope during constant hypercapnia. Under conditions of oscillating pCO2, the temporal and spatial postprandial increase in ammonia nitrogen excretion was significantly reduced. This group also excreted significantly less ammonia after ingesting a meal. No significant effects on the magnitude or duration of postprandial ammonia excretion were observed at high pCO2 or low pH/normocapnia. The results demonstrate that despite an exceptional tolerance towards elevated pCO2 and acidosis, postprandial metabolic processes of the European eel are adversely affected by hypercapnia and low pH.

**General information**

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Organisations: National Institute of Aquatic Resources, Section for Aquaculture
Authors: Methling, C. (Ekstern), Pedersen, P. B. (Intern), Steffensen, J. F. (Ekstern), Skov, P. V. (Intern)
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- BFI (2009): BFI-level 1
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- Web of Science (2009): Indexed yes
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Mesh size effects on water quality in replicated Recirculating Aquaculture Systems

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Authors: Fernandes, P. (Intern), Pedersen, L. (Intern), Pedersen, P. B. (Intern)
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Event: Abstract from 2nd Workshop on Recirculating Aquaculture System, Aalborg, Denmark.
Main Research Area: Technical/natural sciences
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Nitrogen waste load from juvenile rainbow trout (Oncorhynchus mykiss)

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Organisations: National Institute of Aquatic Resources, Section for Aquaculture
Authors: Dalsgaard, A. J. T. (Intern), Larsen, B. K. (Intern), Pedersen, P. B. (Intern)
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Publication: Research › Conference abstract for conference – Annual report year: 2013

Nutrient digestibility and growth in rainbow trout (Oncorhynchus mykiss) are impaired by short term exposure to moderate supersaturation in total gas pressure

Excess levels of dissolved nitrogen gas (N2) may occur in recirculating aquaculture systems, as a result of aeration efforts, localized occurrences of denitrification, or from insufficient degassing of makeup water. If levels of dissolved N2 are sufficiently high, or if oxygen (O2) is also maintained at or above saturation, this leads to a supersaturation in total gas pressure (TGP). Depending on severity, total gas pressures above saturation may lead to gas bubble trauma, evident by visual inspection of the fish. Physiological effects of subclinical levels of TGP are not well known and have not been investigated for rainbow trout. The present study examined the effects of N2 supersaturation, with or without simultaneous excess TGP. Supersaturation with N2 (ΔP 22mmHg) without total gas supersaturation (ΔTGP −6mmHg) did not have any significant effects on feed intake, feed conversion or growth. Short term (16days) exposure to N2 supersaturation (ΔP 36mmHg) in combination with a ΔTGP of 23mmHg did not affect feed intake, nor did it cause GBT or any apparent changes in behaviour. Excess TGP did, however, significantly reduce apparent lipid digestibility, feed conversion, and the thermal growth coefficient, compared to control treatments in which N2 and O2 were maintained below saturation levels.
In addition to a significant decrease in available metabolizable energy (energy intake corrected for faecal loss), this group also had significantly higher cost of growth. These results suggest that even moderate TGP supersaturation negatively affect aquaculture production by a dual effect on energy uptake and energy expenditure, possibly caused by a general stress response to dissolved gases. Continuing the experiment over 25 days eliminated any significant differences on production variables, suggesting that rainbow trout exposed to moderate excess levels of TGP for longer periods were able to adapt to some degree.

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Scopus rating (2016): CiteScore 2.75 SJR 1.101 SNIP 1.524
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Web of Science (2015): Indexed yes
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Scopus rating (2014): SJR 1.002 SNIP 1.34 CiteScore 2.16
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.136 SNIP 1.3 CiteScore 2.18
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.212 SNIP 1.487 CiteScore 2.32
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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
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.151 SNIP 1.394
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.941 SNIP 1.263
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 0.909 SNIP 1.173
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.019 SNIP 1.318
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.008 SNIP 1.689
Nutritional value of mussel meal in fish feed: a sustainable, high-quality protein source

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Authors: Larsen, B. K. (Intern), Dalsgaard, A. J. T. (Intern), Pedersen, P. B. (Intern), Baardsen, G. (Ekstern), Hansen, A. (Ekstern), Jokumsen, A. (Intern)
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Preface: Recirculation technology: science meets practice

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Removal of nitrogen, phosphorous and organic matter in a constructed wetland treating effluents from a Model Trout Farm

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Aquaculture
Authors: Dalsgaard, A. J. T. (Intern), von Ahnen, M. (Ekstern), Pedersen, P. B. (Intern)
Publication date: 2013
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Main Research Area: Technical/natural sciences
Publication: Research › Poster – Annual report year: 2013

Effects of exogenous enzymes on apparent nutrient digestibility in rainbow trout (Oncorhynchus mykiss) fed diets with high inclusion of plant-based protein

General information
State: Published
Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Dalsgaard, A. J. T. (Intern), Verlhac, V. (Ekstern), Hjermitslev, N. (Ekstern), Ekmann, K. S. (Intern), Fischer, M. (Ekstern), Klausen, M. (Ekstern), Pedersen, P. B. (Intern)
Effects of feed loading on nitrogen balances and fish performance in replicated recirculating aquaculture systems

This study investigated the effects of applying four fixed feed loadings to three replicated recirculating aquaculture systems (RAS) on water quality changes, nitrogenous balances and growth performance of rainbow trout (Oncorhynchus mykiss). Feed loadings ranged from 1.6 to 6.3 kg feed/m³ make-up water, with a constant make-up water renewal of 4.7% of total water volume per day in all twelve RAS. Fish densities ranged from 14 to 92 kg/m³ during the prolonged trial of 10 weeks. Selected water quality parameters were measured during two intensive sampling campaigns, evaluating biofilter nitrification performance and diurnal patterns of total ammonia nitrogen (TAN) and nitrite concentrations. No fish mortality occurred during the study. Feed conversion ratios varied between 0.91±0.04 and 0.95±0.02, and were unaffected by feeding load. Mean nitrate-nitrogen levels ranged from 54±7 to 196±10 mg/L at steady state, and the concentration of nitrogenous compounds and organic matter were all positively correlated to feed loading. The TAN loading to the RAS from the specific feed type was assessed in a separate mass-balance study and used as input in a descriptive mathematical model (AQUASIM® software) developed to simulate processes affecting N mass-balances in the RAS. Nitrification kinetic rate constants were applied to the biofilter, and fractions of nitrifiers in suspended solids in the water phase were estimated based on existing information from waste water treatment processes. Two model scenarios successfully simulated the measured TAN concentration in the experimental RAS. The first model scenario applied a first-order area-based nitrification rate (k1a) constant of 0.2 m/d, estimating a fraction of active nitrifiers (fN) in the water phase of 4% of the total suspended solids. The second model scenario used a k1a of 0.1, estimating a fN of 8% with similar predictability as in the first scenario. Overall, this study provided new information on fish performance and resulting water quality during steady state RAS operation. Furthermore, the study demonstrated that kinetic modeling can be applied to simulate measured TAN concentrations in experimental RAS.

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Organisations: Section for Aquaculture, National Institute of Aquatic Resources, Urban Water Engineering, Department of Environmental Engineering
Authors: Pedersen, L. (Intern), Suhr, K. I. (Intern), Dalsgaard, A. J. T. (Intern), Pedersen, P. B. (Intern), Arvin, E. (Intern)
Pages: 237-245
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Main Research Area: Technical/natural sciences

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BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
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Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Web of Science (2015): Indexed yes
Scopus rating (2016): CiteScore 2.75 SJR 1.101 SNIP 1.524
Web of Science (2016): Indexed yes
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Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.002 SNIP 1.34 CiteScore 2.16
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.136 SNIP 1.3 CiteScore 2.18
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.212 SNIP 1.487 CiteScore 2.32
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.294 SNIP 1.542 CiteScore 2.39
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.

General information

State: Published
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 conditions. Acute crowding stress increased plasma cortisol to above 120 ng ml−1 in all conditions. Acute crowding stress increased plasma cortisol to above 120 ng ml−1 in all conditions. Acute crowding stress increased plasma cortisol to above 120 ng ml−1 in all conditions.

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.
Hydrogen peroxide application to a, commercial recirculating aquaculture system

General information
State: Published
Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Pedersen, L. (Intern), Pedersen, P. B. (Intern)
Pages: 40-46
Publication date: 2012
Low-dose hydrogen peroxide application in closed recirculating aquaculture systems

The aim of the present work was to simulate water treatment practices with hydrogen peroxide (HP) in recirculating aquaculture systems (RAS). Six identical 1,700-L pilot-scale RAS were divided into two experimental groups based on daily feed allocation and operated under constant conditions for a period of 3 months. The organic and nitrogenous loadings of the systems differed fourfold between the two groups and were achieved by predefined constant daily feed loads and constant additions of water. The fixed cumulative feed burden was $1.6 \times 10^3$ mg feed/L in the low-intensity RAS and $6.3 \times 10^3$ mg/L in the high-intensity RAS. The decay of HP in rearing tanks and disconnected biofilter units was investigated by means of HP spiking experiments. The decay in high-intensity RAS rearing units and biofilters was orders of magnitude faster than that in low-intensity units. The application of HP impaired biofilter nitrite oxidation in low-intensity RAS but not in high-intensity RAS. The impact of HP exposure time on biofilter nitrification capacity was then assessed in biofilter bench-scale experiments with nitrite spiking. Exposure time was found to significantly affect nitrite oxidation. Compared with unexposed biofilter elements, nitrite oxidation was reduced more than 90% following 3 h of exposure to 15 mg HP/L, whereas 30 min of exposure had only minor negative effects on nitrite oxidation. The findings of this study demonstrate the potential for developing HP water treatment practices for RAS and contradict prevailing notions that HP cannot be used safely in RAS that employ biofiltration. The development of effective new HP treatment protocols for recirculating aquaculture could reduce the current dependence on formalin to improve water quality and control parasitic loads.

General information
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Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Pedersen, L. (Intern), Good, C. (Ekstern), Pedersen, P. B. (Intern)
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Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.438 SNIP 0.719 CiteScore 0.85
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.436 SNIP 0.516 CiteScore 0.7
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.384 SNIP 0.61 CiteScore 0.69
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.338 SNIP 0.502 CiteScore 0.52
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.401 SNIP 0.745 CiteScore 0.79
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.442 SNIP 0.868 CiteScore 0.8
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.32 SNIP 0.539
BFI (2009): BFI-level 1
Move or rest: Nitrification performance of fixed bed and moving bed biofilters

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Aquaculture
Authors: Pedersen, L. (Intern), Nielsen, J. (Ekstern), Pedersen, P. B. (Intern)
Publication date: 2012
Main Research Area: Technical/natural sciences
Publication: Research › Conference abstract for conference – Annual report year: 2012

Optimering af driften på klassiske dambrug

General information
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Organisations: National Veterinary Institute, Section for Bacteriology, Pathology and Parasitology, National Institute of Aquatic Resources, Section for Aquaculture, Sektion, Parasitology and Aquatic Diseases, Aarhus University, Dansk Akvakultur
Authors: Buchmann, K. (Forskerdatabase), Dalsgaard, I. (Intern), Dalsgaard, A. J. T. (Intern), Pedersen, P. B. (Intern), Svendsen, L. M. (Forskerdatabase), Henriksen, N. H. (Ekstern), Michelsen, K. (Ekstern), Thomsen, B. (Ekstern)
Number of pages: 12
Publication date: 2012

Test and implementation of easy degradable aquaculture sanitizers

General information
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Trout farming in Denmark: recent trends and future prospects

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Organisations: National Institute of Aquatic Resources, Section for Aquaculture
Authors: Dalsgaard, A. J. T. (Intern), Pedersen, P. B. (Intern)
Pages: 2-4
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Main Research Area: Technical/natural sciences

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Links: http://www.aesweb.org/newsletters.html
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Controlling effluents from RAS – waste management strategies important for commercial RAS sustainability

General information
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Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Pedersen, P. B. (Intern), Suhr, K. I. (Intern), Pedersen, L. (Intern)
Publication date: 2011

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Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 276720
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Dambrugsteknologi – reduktion af kvælstofudledning fra Modeldambrug: Test af denitrifikationsfiltrer

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Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Suhr, K. I. (Intern), Pedersen, P. B. (Intern)
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Main Research Area: Technical/natural sciences
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Influence of feed ingredients on water quality parameters in RAS

Although feed by far is providing the major input to RAS, relatively little is published about the correlation between feed composition and the resulting water quality in such systems. In a set-up with 6 identical RAS, each consisting of a fish tank (0.5 m³), a swirl separator, a submerged biofilter (0.67 m³/100 m²) and a trickling filter (0.17 m³/33 m²), two different feed types were tested in a triplicate set-up. The two feed types used were identical recipes (44% protein, 30% fat) except for the inclusion of 0.2 % guar gum (Grindsted Guar, Danisco) in one of the types. The inclusion level of plant-based protein in the diets was relatively high (68% of protein). Growth performance (SGR, FCR) was not different between the feed types. Fish in each system – and thereby the system itself – were fed 500 g feed/day. After 8 weeks on the same commercial feed type, test feed was administered to the systems for 49 consecutive days. Each week, 24h-water samples (1 sample/hour) were collected from each system. The sludge collected in the swirl separator that day was also collected. Water and sludge were subsequently analysed for nitrogen, phosphorous and organic matter content. Inclusion of guar gum had impact on water quality in the systems as well as on matter removed by the swirl separators. In the RAS water, phosphorous (Ptot and Pdiss) concentrations were reduced by guar gum. Organic matter content (CODdiss) in the water was also reduced. Corresponding to this, more dry matter, more COD and more phosphorous were removed by the swirl separators. As might be expected from the high protein digestibility (determined in a separate study), no effects were generally observed on nitrogen compounds.
Marine Model Trout Farms: developments in marine RAS

Economical and environmentally sustainable production of large salmonids in sea water has in Denmark been called for during some years. Based on the experience gained from the Danish Model Trout Farms in freshwater, a rather similar concept has been developed for farming of larger fish in sea water. This development and demonstration unit in commercial scale will during the next four years hopefully provide scientific and practical basis and support for further development in coming generations of Marine Model Trout Farms for large salmonids. The unit consist in the recirculation loop of one large fish tank, ø25 m, depth 4.5 m, i.e. tank volume some 2,000 m³; a drum filter (HydroTech); 9 separate pumps (Grundfos NB 150-200/224), 2 for each of 3 submerged biofilter-sections and 3 pumps bypassing the submerged biofilters, leading directly to the large trickling filter where the water from the submerged biofilters also enter. Each submerged biofilter contains 22.6 m³ filter elements (RK BioElements 750 m²/m³; RK plast) and the trickling filters contains 90 m³ (BioBlock 200, Exponent). From the trickling filter water is led directly back to the fish tank. According to fish stock, feeding level and water temperature the pumps can be individually turned on/off primarily in relation to oxygen need and consumption in the fish tank. In a 1 year batch production some 20 t of fish will be introduced in April and some 80 t are supposed to be harvested in December. End-of-pipe treatment is a two-step process. First, nitrogen is removed in a full-scale experimental set-up where sludge from the drum filter is hydrolysed and the VFAs generated used as energy-source for the denitrification process in separate tanks/filters. Final polishing follows in a constructed wetland. For the first 2 years of operation production will be focussed on rainbow trout production, mimicking the typical Danish net cage farming cycle, where the cages are stocked with fish of 750 – 1,000 g in April/May and all harvested before Christmas weighing some 4 kg/pcs. During these two years important production parameters such as growth-rate, feed conversion and pigmentation will be compared to net-cage results and a full-cost comparison will be performed. After 2 years Atlantic salmon will be farmed in all-year operation. The project is supported by the Danish GUDP joint cooperation between research and industry, and the participants are: The North Sea Center (facilities); AquaPri (fish producer); Biomar (feed producer); Billund Aquaculture (system supplier); RK Plast (producer of biofilter elements) and DTU Aqua. Facts, Experience gained, facts and figures will be presented.
Solid and suspended/dissolved waste (N, P, O) from rainbow trout (Oncorhynchus mykiss)

Quantifying aquaculture waste into different waste fractions will make it possible to design different treatment setups for obtaining specific cleaning objectives. The aim of this study was therefore to measure "all" solid and suspended/dissolved (i.e. unsedimented) waste from juvenile rainbow trout (Oncorhynchus mykiss) fed three commonly applied commercial diets, "all" waste referring to: total nitrogen (N), total ammonia nitrogen (TAN=NH3-N+NH4-N), total phosphorus (P), and organic matter characterized by the chemical oxygen demand (COD) and the biological oxygen demand after 5 days (BOD5). Furthermore, it was hypothesized that solid COD waste can be calculated from undigested nutrients. Two experiments were carried out using a modified Guelph System. Nitrogen and phosphorus wastewas derived from mass-balances based on all measured values in the first experiment. Apparent digestibility coefficients (ADCs) were used to calculate the solid amounts of undigested nutrients. These were subsequently used for calculating the solid COD output, verified by direct COD measurements. The output of solid and suspended/dissolved BOD5 and COD was measured in the second experiment. There were just minor differences between the dietary treatment groups in the waste produced. On average, 48% of the ingested N was recovered in the water (TAN constituting 64–79% of this) and 7% in the solids. In comparison, 1% of the ingested P was recovered in the water and 43% in the solids. A breakpoint value of 5.6 g standardized available P kg−1 dry feed was found, below which the dissolved P excretion was minimal and above which it increased rapidly. More COD was recovered as solid waste than as suspended/dissolved waste, while it was opposite for BOD5. A BOD5/COD ratio of 0.5 indicated that the suspended/dissolved waste was characterized by easily degradable organic matter, while a solid BOD5/COD ratio of 0.2 indicated that this waste fraction contained high amounts of hard-to-degrade organic matter. Finally, the study showed that solid COD waste can be quite accurately calculated from the composition and content of undigested nutrients.
Test af denitrifikationsfiltre på Modeldambrug: Fra: Dambrugsteknologi. Samlerapport

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Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Suhr, K. I. (Intern), Pedersen, P. B. (Intern)
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Towards environmentally sustainable aquaculture: Exploiting fermentation products from anaerobic sludge digestion for fueling nitrate removal in RAS

Aquaculture is the world’s fastest growing food production sector (FAO, 2007). The continuous growth in many countries, however, relies heavily on the ability to reduce the emission of nutrients and chemicals from the fish farms. A way to manage and treat the nutrient aquaculture wastes is by production in recirculating aquaculture systems (RAS). In Denmark, more than 50 % of total fresh-water rainbow trout production is made in semi-intensive RAS, called ModelTrotFarms (MTF). MTF efficiently removes organic matter (93%), phosphorous (76%), and nitrogen (50%) (Svendsen et al., 2008). This makes nitrogen the limiting process parameter for further environmentally viable increase in production. Nitrogen removal is a two step transformation process, with (1) ammonia-N oxidation to nitrate-N in the RAS’ biofilter, and subsequently (2) nitrate-N reduction to N2 in the constructed wetlands. The latter being the final cleaning component of the MTF set-up. No specific denitrification filter has so far been implemented in Danish MTFs. An in-situ study was conducted at a commercial MTF (1000 ton/year) for evaluating the potential of using the fermentation products from anaerobic digestion in the sludge storage basins, to fuel denitrification in specific denitrification filters. In experimental filters (5.5 m3) nitrate-containing outlet water was mixed with drainage water from the sludge storage basins according to a factorial design varying C/N ratio from 4 to 12 (CODs/NO3-N) and hydraulic retention time (HRT) from 50 to 180 min. The highest removal rate recorded, 125 g NO3-N/m3reactor/d, was found in treatments at the design center point, and multivariate response surface analysis modeled a maximum N-removal at C/N ratio of 8.8 and HRT of 114 min. The effect of C/N ratio depended on the HRT: At low HRT, variation in C/N ratio had no effect on N-removal. On the contrary, at high HRT, the highest N-removal was measured at high C/N ratio but significant ammonia-N was simultaneously produced, most probably by dissimilatory nitrate reduction to ammonia (DNRA). Running the filters at high HRT and low C/N ratio rendered a relatively lower nitrate-N removal rate but significantly higher ammonia-N reduction, which could indicate anaerobic ammonia oxidation (anammox) activity. A controlled laboratory anaerobic MTF sludge digestion experiment showed that app. 40% additional nitrate-N reduction could theoretically be achieved if implementing the use of fermented sludge as carbon source for denitrification. Besides the N-reduction, the directly linked sludge (organic matter) reduction is a beneficial side effect of such an operational set-up

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Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Suhr, K. I. (Intern), Pedersen, P. B. (Intern)
Number of pages: 52
Publication date: 2011
Effects of supplemental enzymes on apparent nutrient digestibility in rainbow trout (Oncorhynchus mykiss) fed plant-based diets

Exogenous enzymes are widely applied in feed for monogastric animals including pigs and poultry as a means to increase the nutritional value of viscous grains by reducing the anti-nutritional effects of primarily non-starch polysaccharides (NSPs). In comparison, there is very limited information on the effects of enzymes in fish feed apart from phytase. Phytase works by hydrolyzing phytic acid, and numerous studies have documented that phytase supplementation increases phosphorus availability in fish fed diets with high inclusion levels of plant proteins. Plant derived proteins are increasingly used in fish feed due to growing demands for and high price variations in fish meal, but high inclusion levels in diets for carnivorous fish are hampered by a great variety of anti-nutritional factors (ANFs), which reduce nutrient utilisation. Exogenous dietary enzymes may potentially help to alleviate these effects, and the objective of the present study was to evaluate the effects of supplementing protease and pectinase to a diet containing approximately 30% soybean meal, rapeseed meal or sunflower meal on nutrient digestibility in juvenile rainbow trout (Oncorhynchus mykiss). Digestibility trials were carried out using a modified Guelph set-up. Rainbow trout were fed the un-supplemented diets and enzyme supplemented plant-based diets in triplicates for three weeks. While moderate effects of the enzymes on nutrient digestibility were obtained with sunflower and rapeseed meal based diets, both enzymes significantly increased (P < 0.05) the apparent digestibility coefficients (ADCs) of protein, lipid and nitrogen-free extract (NFE) in soybean meal based diets. Hence, the study provided preliminary results on the potential of protease and pectinase to increase the nutritional value of proteinaceous feed ingredients for fish. However, it also reinforces the complexity of using exogenous dietary enzymes and that more research is required to better understand the mechanisms of actions.

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Authors: Dalsgaard, A. J. T. (Intern), Hjermitslev, N. H. (Ekstern), Ekmann, K. S. (Intern), Verlhac, V. (Ekstern), Pedersen, P. B. (Intern), Klausen, M. (Ekstern)
Publication date: 2010

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Hydrogen peroxide: Disinfectant for recirculating aquaculture systems

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Authors: Pedersen, L. (Intern), Pedersen, P. B. (Intern)
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ISI indexed (2011): ISI indexed no
Long term/low dose formalin exposure to small-scale recirculation aquaculture systems

Repetitive long term formalin application at low dose was investigated to determine the effect on formaldehyde removal rate, biofilter nitrification and the microbial composition in small-scale recirculation aquaculture biofilters. Six pilot-scale recirculation aquaculture systems holding rainbow trout (Oncorhynchus mykiss) were designated to formalin treatments (C-0 at 10 and 20mg/L formaldehyde) on a daily or weekly basis. Formaldehyde removal rates were measured over 10 weeks, during which biofilter nitrification rates were measured in terms of standardized NH4Cl spiking events. The rates were positively correlated to the amount and frequency of formalin treatment. In systems with regularly low formalin dosage, the formaldehyde removal rate increased up to tenfold from 0.19 +/- 0.05 to 1.81 +/- 0.13 mg/(L h). Biofilter nitrification was not impaired in systems treated with formalin on a daily basis as compared to untreated systems. In systems intermittently treated with formalin, increased variation and minor reductions of ammonium and nitrite oxidation rates were observed. Nitrifying bacteria were screened by specific gene probes using fluorescence in situ hybridization and quantified by digital image analysis. The relative abundance of ammonia-oxidizing bacteria (AOB) was up to 5.4% of all Bacteria (EUB) positive cells, predominantly Nitrosomonas oligotropha. Nitrite-oxidizing bacteria (NOB), mainly consisting of Nitrospira sp. were found in all biofilm samples up to 2.9%, whereas Nitrobacter sp. was not detected. The relative abundances of AOB and NOB in the untreated system were generally higher compared to the system exposed to formalin. Low dose formalin in recirculated aquaculture systems proved to be a possible treatment strategy, as the effect on nitrification was minimal. Since formaldehyde was steadily removed by microorganisms, available biofilter surface area, hydraulic retention time and temperature can be used to predict removal and hence estimate e.g. effluent concentration, (C) 2009 Elsevier B.V. All rights reserved.
Nitrification in moving bed and fixed bed biofilters treating effluent water from a large commercial outdoor rainbow trout RAS

The nitrification performance of two fixed bed (FB) biofilters and two moving bed (MB) biofilters was evaluated. They received the same cold (8 degrees C) influent water from a commercial outdoor RAS facility producing rainbow trout (average density 32 kg m(-3)). The filters were constructed as four identical 5.5 m(3) tanks with different filter media inside
and tested simultaneously in duplicate. FB filters were filled with 4.2 m(3) polyethylene netshaped cylinders (Bioblok (R), 200 m(2):n(-3)), and MB filters with 2 m(3) polypropylene carriers (Biomedia, 850 m(2):m(-3)). Nitrification rates were measured 3(1/2) months after start-up, and inlet water was supplemented with ammonium chloride in order to determine maximum nitrification rates (0-order kinetics). The filters were conditioned at in inlet TAN concentration of 2.89 +/- 0.1 mg l(-1) and water in-flow ranging from 1 l s(-1) to 4 l s(-1). Expressed as volumetric total ammonia-N (TAN) removal rate, the MB filters had significantly higher removal rate (23 +/- 17 g N-1 m(-3) d(-1)) compared to the FB filters (92 +/- 2 g N-1 m(-3) d(-1)). Expressed as surface specific TAN removal rate MB filters had significantly lower removal (0.27 +/- 0.02 g m(-2) d(-1)) than FB filters (0.46 +/- 0.01 g m(-2) d(-1)). When conditioned to a higher inlet TAN concentration (6.27 +/- 0.39 mg l(-1)) for 2 weeks, the FB filters increased the removal rate (146 +/- 3 g m(-3) d(-1) or 0.73 +/- 0.01 g m(-2) d(-1)) while the MB filters had unaltered performance. The results indicate, that the more heterogeneous and stratified biofilm to be expected in FB, can react more flexibly when challenged with changes such as differences in TAN loading. The effect of dissolved oxygen level on FB filter nitrification rates was additionally tested at TAN 5.35 +/- 0.06 mg l(-1). Below approximately 60% saturation (7.1 mg O-2 l(-1)) measured at the filter outlet, nitrification rates started decreasing rapidly. An exponential expression (y = -10.05 + 10.48(1 - e(-0.0798x)), R-2=0.96) was found to model the whole data range from 40% to 80% DO saturation well. (C) 2009 E sevier B.V. All rights reserved.

**General information**

State: Published
Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Suhr, K. (Intern), Pedersen, P. B. (Intern)
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**Publication Information**

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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.09 SJR 0.798 SNIP 1.525
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.723 SNIP 1.148 CiteScore 1.63
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.72 SNIP 1.437 CiteScore 1.61
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.666 SNIP 1.511 CiteScore 1.8
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.946 SNIP 1.377 CiteScore 1.72
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.69 SNIP 1.406 CiteScore 1.54
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.55 SNIP 0.945
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.717 SNIP 1.424
The effects of grading on the growth and survival of juvenile Dover sole (Solea solea L)

A 3-month study was carried out to investigate the effects of grading on the overall production, growth performance and survival of juvenile Dover sole (Solea solea L.). Juvenile fish (4.0–40.4 g) were sorted into three size groups: small (4.0–15.5 g), medium (16.0–21.5 g) and large (22.0–40.5 g). In addition, a group of unsorted fish was followed for comparison. The fish from each sorted group and the unsorted group were divided between triplicate tanks at a stocking density of 1.5 kg m\(^{-2}\). The fish were weighed and counted 21, 42, 63 and 92 days after stocking. In addition, 30 randomly chosen fish in each tank (=90 from each group) were individually tagged. The survival, size distribution, growth and productivity were calculated for small, medium, large and unsorted groups. In addition, comparisons were made between combined sorted and unsorted fish. There was no significant difference between the mean weight and distribution of sorted and unsorted fish by the end of the trial. An increased overall productivity in combined sorted fish was observed. Regular grading could therefore still be beneficial for sole farming as long as the grading interval supports maximum growth (in this case over 90 days). Survival was not significantly affected by the grading process.
Danish model trout farms – Technology and environmental impact

General information
State: Published
Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Jokumsen, A. (Intern), Plesner, L. J. (Ekstern), Pedersen, P. B. (Intern), Dalsgaard, A. J. T. (Intern), Lund, I. (Intern), Paulsen, H. (Intern), Rasmussen, R. S. (Intern)
Publication date: 2009
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 252713
Publication: Research › Conference abstract for conference – Annual report year: 2009

Effect of supplemented fungal phytase on performance and phosphorus availability by phosphorus-depleted juvenile rainbow trout (Oncorhynchus mykiss), and on the magnitude and composition of phosphorus waste output

The effect of a supplemental fungal phytase on performance and phosphorus availability by juvenile rainbow trout fed diets with a high inclusion of plant based protein and on the magnitude and composition of the waste phosphorus production was tested in a 2 × 3 factorial design at a temperature of 11 °C. Two factors comprised of two dietary fungal phytase levels (0 or 1400 U kg⁻¹ feed⁻¹), and three dietary total phosphorus levels (0.89, 0.97 or 1.12%). All fish were acclimated to the lowest total phosphorus diet for 16 days, which included 0.29% phytate-phosphorus and no supplemental fungal phytase, to ensure that they were depleted of phosphorus prior to the feeding trial. Growth and feed conversion ratios were not significantly affected by the increasing dietary phosphorus level or supplemental fungal phytase. Phosphorus availability increased significantly as a result of phytase supplementation, reaching an upper level of 74% at an available dietary phosphorus concentration of 0.71%. Adding fungal phytase to the diets improved the availability of phytate-phosphorus from an average of 6 to 64%. The fish retained 53–79% of the ingested phosphorus, while 24–44% was recovered in the faeces. The particulate phosphorus waste output was significantly higher in faeces from fish fed diets without fungal phytase compared to fish fed phytase supplemented diets. The dissolved/suspended phosphorus waste output represented 2–13% of the ingested phosphorus, and there was a significant increase in the dissolved/suspended phosphorus waste output from fish fed the phytase supplemented diet containing 0.71% available phosphorus, suggesting that the phosphorus requirement was reached at this phosphorus level. Consistent with this, there was a substantial increase in the dissolved/suspended phosphorus waste output from fish fed the phytase supplemented diet containing 0.81% available phosphorus, suggesting that the phosphorus requirement was exceeded in this group. This study demonstrated that phytase supplementation will be advantageous to the fish and the environment if supplemented to low-phosphorus diets containing a large share of plant-derived protein. Conversely, the results demonstrated that fungal phytase should not be supplemented to diets in which the available phosphorus level already meets the requirement of the fish, as this will lead to a significant increase in the dissolved/suspended phosphorus waste output.

General information
State: Published
Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Dalsgaard, A. J. T. (Intern), Schøn Ekmann, K. (Ekstern), Pedersen, P. B. (Intern), Verlhac, V. (Ekstern)
Pages: 105-112
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Main Research Area: Technical/natural sciences

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Scopus rating (2016): CiteScore 2.75 SJR 1.101 SNIP 1.524
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Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.002 SNIP 1.34 CiteScore 2.16
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.136 SNIP 1.3 CiteScore 2.18
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
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Scopus rating (2012): SJR 1.212 SNIP 1.487 CiteScore 2.32
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.294 SNIP 1.542 CiteScore 2.39
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.151 SNIP 1.394
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.941 SNIP 1.263
Web of Science (2009): Indexed yes
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Scopus rating (2008): SJR 0.909 SNIP 1.173
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.019 SNIP 1.318
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.008 SNIP 1.689
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.915 SNIP 1.236
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.016 SNIP 1.627
Web of Science (2004): Indexed yes
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
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 0.908 SNIP 1.113
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 1.049 SNIP 1.251

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Phosphorus, Phytic acid, Phytase, Waste output, Budget
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Hydrogen peroxide application in recirculating aquaculture systems - results and perspectives

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State: Published
Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Pedersen, L. (Intern), Pedersen, P. B. (Intern)
Publication date: 2009

Host publication information
Title of host publication: Abstracts from World Aquaculture 2009, Veracruz Mexico, Sept. 2009
Main Research Area: Technical/natural sciences
Source: orbit
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Publication: Research › Conference abstract in proceedings – Annual report year: 2009

Lejstrup Dambrug (øst) - et modeidambrug under forsøgsordningen: Statusrapport for 2. måleår af moniteringsprojektet med væsentlige resultater fra første måleår

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State: Published
Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Svendsen, L. M. (Ekstern), Sortkjær, O. (Ekstern), Ovesen, N. B. (Ekstern), Skriver, J. (Ekstern), Larsen, S. E. (Ekstern), Pedersen, P. B. (Intern), Rasmussen, R. S. (Intern), Dalsgaard, A. J. T. (Intern)
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New methods in trout farming to reduce the farm effluents - Case study in Denmark

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Organisations: Section for Aquaculture, National Institute of Aquatic Resources, Section for Aquatic Process and Product Technology
Authors: Jokumsen, A. (Intern), Pedersen, P. B. (Intern), Dalsgaard, A. J. T. (Intern), Lund, I. (Intern), Paulsen, H. (Intern), Rasmussen, R. S. (Intern), Hyldig, G. (Intern)
Number of pages: 111
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Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Svendsen, L. M. (Ekstern), Sortkjær, O. (Ekstern), Ovesen, N. B. (Ekstern), Skriver, J. (Ekstern), Larsen, S. E. (Ekstern), Pedersen, P. B. (Intern), Rasmussen, R. S. (Intern), Dalsgaard, A. J. T. (Intern)
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http://www.aqua.dtu.dk/Publikationer/Forskningsrapporter/Forskningsrapporter_siden_2008
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Source-ID: 256052
Publication: Research › Report – Annual report year: 2009

Peracetic acid degradation and effects on nitrification in recirculating aquaculture systems

General information
State: Published
Organisations: Section for Aquaculture, National Institute of Aquatic Resources, Aalborg University
Authors: Pedersen, L. (Intern), Pedersen, P. B. (Intern), Nielsen, J. L. (Ekstern), Nielsen, P. .. (Ekstern)
Pages: 246-254
Publication date: 2009
Main Research Area: Technical/natural sciences

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|------|----------------------|-----------------------|------------|----------------------|-----------------------|------------|----------------------|-----------------------|------------|----------------------|-----------------------|------------|----------------------|-----------------------|------------|----------------------|-----------------------|------------|----------------------|-----------------------|------------|----------------------|-----------------------|------------|----------------------|-----------------------|------------|----------------------|-----------------------|------------|----------------------|-----------------------|------------|----------------------|-----------------------|------------|----------------------|-----------------------|------------|----------------------|-----------------------|------------|----------------------|-----------------------|
Peracetic acid degradation and effects on nitrification in submerged fixed bed biofilters from recirculating aquaculture systems

General information
State: Published
Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Pedersen, L. (Intern), Pedersen, P. B. (Intern), Nielsen, J. (Ekstern), Nielsen, P. (Ekstern)
Publication date: 2009

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Title of host publication: Abstracts from World Aquaculture 2009, Veracruz Mexico, Sept. 2009
Main Research Area: Technical/natural sciences
Source: orbit
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Publication: Research › Conference abstract in proceedings – Annual report year: 2009

Recovery by the Norway lobster Nephrops norvegicus (L.) from the physiological stresses of trawling: Influence of season and live-storage position
Live Norway lobsters (Nephrops norvegicus L.) were trawled at depths of 30 to 55 m off the coast of Jutland (Denmark) in late winter (March) and in summer (August) in 2006. Water temperatures at the bottom and surface of the sea were 7 °C and 2 °C during the winter, and 12 °C and 21 °C in the summer, respectively. The recovery of specific physiological and metabolic variables from the intense stresses associated with capture (trawling and air-exposure during sorting) was followed in seawater at 5 °C in winter or 18 °C in summer. Recovery was compared in lobsters held individually in two different live-storage positions, either resting vertically on the tail or sitting horizontally. In winter, many animals were alive when brought on board and approximately 86% were still alive at the end of experimentation (96 h). In summer very few animals were alive when brought on board and, of these, approximately 95% were dead at 24 h. When compared with values measured in laboratory controls, the stresses of capture elicited very high haemolymph lactate contents in both seasons, although levels recovered within 24 h. Trawling also caused very high haemolymph glucose concentrations, which differed with season. In winter, haemolymph glucose was elevated for 24 h to levels significantly higher than in summer. In summer, glucose had returned to control levels by 4 h. At 4 h after trawling, haemolymph O2 status was not markedly influenced in either season, but there were significant disturbances of acid-base status. In winter, a potential metabolic lactic acidosis was compensated by a marked respiratory alkalosis, with significantly increased haemolymph pH and decreased CO2 total content and partial pressure. These effects disappeared gradually over 96 h. Summer lobsters showed combined metabolic and respiratory acidosis at 4 h, although this had recovered to control values in the small number of survivors sampled at 24 h. The capture stresses elicited very high haemolymph crustacean hyperglycaemic hormone (CHH) titres, significantly higher in summer than in winter. In winter, CHH titre had declined significantly at 24 h, whereas it exhibited a further significant increase at 24 h in summer. Live-storage position had no significant effect on survival or recovery from capture stresses in either season. The results demonstrate that Nephrops were much more stressed by trawling at high summer temperatures and had difficulty recovering from this, with pronounced negative effects on their survival, irrespective of their live-storage position.

General information
State: Published
Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Lund, H. S. (Ekstern), Wang, T. (Ekstern), Chang, E. S. (Ekstern), Pedersen, L. (Intern), Taylor, E. W. (Ekstern), Pedersen, P. B. (Intern), McKenzie, D. (Intern)
Pages: 124-132
Publication date: 2009
Main Research Area: Technical/natural sciences

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Journal: Journal of Experimental Marine Biology and Ecology
Volume: 373
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Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.03 SJR 0.937 SNIP 0.914
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.043 SNIP 0.823 CiteScore 1.87
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.145 SNIP 1.045 CiteScore 2.41
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.294 SNIP 1.08 CiteScore 2.45
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.186 SNIP 1.021 CiteScore 2.27
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.067 SNIP 1.007 CiteScore 2.14
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.239 SNIP 1.017
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.299 SNIP 1.208
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.26 SNIP 1.134
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.214 SNIP 1.308
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.262 SNIP 1.247
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.164 SNIP 1.134
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.091 SNIP 1.121
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.351 SNIP 1.341
Scopus rating (2002): SJR 1.385 SNIP 1.323
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 1.363 SNIP 1.269
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 1.349 SNIP 1.245
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Publication: Research - peer-review » Journal article – Annual report year: 2009

Rens Dambrug - et modeldambrug under forsøgsordningen. Statusrapport for 2.måleår af moniteringsprojektet med væsentlige resultater fra første måleår
Ejstrupholm Dambrug - et modeldambrug under forsøgsordningens. Statusrapport for 2. måleår af moniteringsprojektet med væsentlige resultater fra første måleår

General information
State: Published
Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Svendsen, L. M. (Ekstern), Sortkjær, O. (Ekstern), Ovesen, N. B. (Ekstern), Skriver, J. (Ekstern), Larsen, S. E. (Ekstern), Pedersen, P. B. (Intern), Rasmussen, R. S. (Intern), Dalsgaard, A. J. T. (Intern)
Number of pages: 80
Publication date: 2008

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Title of host publication: Proceedings from the Aquacultural Engineering Society's Fourth Issues Forum

Environmental benefits achieved by applying recirculation technology at Danish trout farms (Model Trout Farm)

General information
State: Published
Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Pedersen, P. B. (Intern), Svendsen, L. (Ekstern), Sortkjær, O. (Ekstern), Ovesen, N. (Ekstern), Skriver, J. (Ekstern), Larsen, S. (Ekstern), Rasmussen, R. S. (Intern), Dalsgaard, A. J. T. (Intern)
Number of pages: 139
Publication date: 2008
Essential fatty acids influence metabolic rate and tolerance of hypoxia in Dover sole (Solea solea) larvae and juveniles

Dover sole (Solea solea, Linneaus 1758) were raised from first feeding on brine shrimp (Artemia sp.) with different contents and compositions of the essential fatty acids (EFA) arachidonic acid (ARA, 20:4n - 6); eicosapentaenoic acid (EPA, 20:5n - 3), and docosahexaenoic acid (DHA, 22:6n - 3), and their metabolic rate and tolerance to hypoxia measured prior to and following metamorphosis and settlement. Four dietary Artemia preparations were compared: (1) un-enriched; (2) enriched with a commercial EFA mixture (Easy DHA SELCO Emulsion); (3) enriched with a marine fish oil combination (VEVODAR and Incromega DHA) to provide a high ratio of ARA to DHA, and (4) enriched with these fish oils to provide a low ratio of ARA to DHA. Sole fed un-enriched Artemia were significantly less tolerant to hypoxia than the other dietary groups. Larvae from this group had significantly higher routine metabolic rate (RMR) in normoxia, and significantly higher O-2 partial pressure (PO2) thresholds in progressive hypoxia for their regulation of RMR (P-crit) and for the onset of agitation, respiratory distress and loss of equilibrium. Metamorphosis was associated with an overall decline in RMR and increase in P-crit, but juveniles fed on un-enriched Artemia still exhibited higher P-crit and agitation thresholds than the other groups. Sole fed un-enriched Artemia had significantly lower contents of EFA in their tissues, both before and after settlement. Thus, enriching live feeds with EFA has significant effects on the respiratory physiology of sole early life stages and improves their in vivo tolerance to hypoxia. We found no evidence, however, for any effect of the ratio of ARA to DHA.

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Organisations: National Institute of Aquatic Resources, Section for Aquaculture
Authors: McKenzie, D. (Intern), Lund, I. (Intern), Pedersen, P. B. (Intern)
Pages: 1041-1051
Publication date: 2008
Main Research Area: Technical/natural sciences

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Web of Science (2017): Indexed Yes
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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
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.204 SNIP 1.041 CiteScore 2.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.272 SNIP 1.064 CiteScore 2.4
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.306 SNIP 1.107 CiteScore 2.43
ISI indexed (2012): ISI indexed yes
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BFI (2011): BFI-level 1
Formaldehyde induced variation in biofilter performance and microbial composition

General information
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Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Pedersen, L. (Intern), Pedersen, P. B. (Intern), Nielsen, J. (Ekstern), Nielsen, P. (Ekstern)
Pages: 430-439
Publication date: 2008

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Main Research Area: Technical/natural sciences
Source: orbit
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Publication: Research › Article in proceedings – Annual report year: 2008
Opdræt af tunge (Solea solea) - undersøgelse af mulighedene for kommercialisering

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Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Pedersen, P. B. (Intern), Lund, I. (Intern), Steenfeldt, S. J. (Intern), Overton, J. L. (Intern), Nunn, M. (Intern)
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200-08_elektronisk_samlet.pdf
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http://www.aqua.dtu.dk/Publikationer/Forskningsrapporter/Forskningsrapporter_siden_2008

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Source-ID: 231195
Publication: Research › Report – Annual report year: 2008

Rationale for restocking the Eastern Baltic cod stock
The Danish Institute for Fisheries Research and Bornholm's Salmon Hatchery examined the potential for restocking Baltic cod (Gadus morhua callarias L.) in the eastern Baltic Sea. This cod population has adapted to the unique brackish water conditions where successful spawning depends on regular inflows of oxygenated saltwater from the North Sea. Hydrographical conditions are therefore considered to constitute the principal bottleneck for recruitment of this population. Successful recruitment is also dependent upon food availability and predation pressure from mainly herring (Clupea harengus L.) and sprat (Sprattus sprattus L.). A 2-to 3-month delay in the spawning period compared to 20-30 years ago has altered feeding conditions and predation susceptibility in a way that may have exacerbated the decline in recruitment. Producing and releasing cod larvae during spring would mimic the spawning period recorded in previous times and would coincide with the spring peak in copepod production. An evaluation of 3 different release scenarios showed that a release of 474 million first-feeding larvae over 5 months would enhance the average population of 2-year-olds by 10% and be biologically and economically the most feasible scenario.

General information
State: Published
Organisations: Section for Coastal Ecology, National Institute of Aquatic Resources, Section for Aquaculture, Section for Population- and Ecosystem Dynamics
Authors: Støttrup, J. (Intern), Overton, J. L. (Intern), Paulsen, H. (Intern), Möllmann, C. (Ekstern), Tomkiewicz, J. (Intern), Pedersen, P. B. (Intern), Lauesen, P. (Intern)
Pages: 58-64
Publication date: 2008
Tingkærvad Dambrug - et modeldambrug under forsøgsordningen. Statusrapport for 2. måleår af moniteringsprojektet med væsentlige resultater fra første måleår

General information
State: Published
Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Svendsen, L. (Ekstern), Sortkjær, O. (Ekstern), Ovesen, N. (Ekstern), Skriver, J. (Ekstern), Larsen, S. (Ekstern), Pedersen, P. B. (Intern), Rasmussen, R. S. (Intern), Dalsgaard, A. J. T. (Intern)
Number of pages: 77
Publication date: 2008
Aspects of respiratory physiology and energetics in rainbow trout (Oncorhynchus mykiss) families with different size-at-age and condition factor

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Aquaculture
Authors: McKenzie, D. (Intern), Pedersen, P. B. (Intern), Jokumsen, A. (Intern)
Pages: 280-294
Publication date: 2007
Main Research Area: Technical/natural sciences

Publication information
Journal: Aquaculture
Volume: 263
Issue number: 1-4
ISSN (Print): 0044-8486
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.75 SJR 1.101 SNIP 1.524
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.103 SNIP 1.254 CiteScore 2.12
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.002 SNIP 1.34 CiteScore 2.16
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.136 SNIP 1.3 CiteScore 2.18
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.212 SNIP 1.487 CiteScore 2.32
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.294 SNIP 1.542 CiteScore 2.39
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.151 SNIP 1.394
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.941 SNIP 1.263
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Løjstrup dambrug (øst) - et modeldambrug under forsøgsordningen: Statusrapport for 1. måleår af moniteringsprojektet

General information
State: Published
Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Svendsen, L. (Ekstern), Sortkjær, O. (Ekstern), Bering Ovesen, N. (Ekstern), Skriver, J. (Ekstern), Larsen, S. (Ekstern), Pedersen, P. B. (Intern), Rasmussen, R. S. (Intern), Dalsgaard, A. J. T. (Intern)
Number of pages: 55
Publication date: 2007

Publication information
Place of publication: Hirtshals
Publisher: Danmarks Fiskeriundersøgelser
ISBN (Print): 978-87-7481-036-0
Original language: Danish
Series: DFU-rapport
Number: 172-07
Main Research Area: Technical/natural sciences
Electronic versions: 172-07, elektronisk_index.pdf
Source: orbit
Source-ID: 226618
Publication: Research - peer-review › Journal article – Annual report year: 2007

Nørå Dambrug - et modeldambrug under forsøgsordningen: Statusrapport for 1. måleår af moniteringsprojektet

General information
State: Published
Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Svendsen, L. (Ekstern), Sortkjær, O. (Ekstern), Ovesen, N. (Ekstern), Skriver, J. (Ekstern), Larsen, S. (Ekstern), Pedersen, P. B. (Intern), Rasmussen, R. S. (Intern), Dalsgaard, A. J. T. (Intern)
Rens dambrug - et modeldambrug under forsøgsordningen: statusrapport for 1. måleår af moniteringsprojektet

General information
State: Published
Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Svendsen, L. (Ekstern), Sortkjær, O. (Ekstern), Ovesen, N. (Ekstern), Skriver, J. (Ekstern), Larsen, S. (Ekstern), Pedersen, P. B. (Intern), Rasmussen, R. S. (Intern), Dalsgaard, A. J. T. (Intern)
Number of pages: 55
Publication date: 2007

Temperature-dependent and surface specific formaldehyde degradation in submerged biofilters

General information
State: Published
Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Pedersen, L. (Intern), Pedersen, P. B. (Intern), Sortkjaer, O. (Ekstern)
Pages: 127-136
Publication date: 2007
Main Research Area: Technical/natural sciences

Publication information
Journal: Aquacultural Engineering
Volume: 36
Issue number: 2
ISSN (Print): 0144-8609
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
The fate of chemical additives and antimicrobial agents applied in Danish freshwater fish farms

General information
State: Published
Organisations: Section for Fish Diseases, National Institute of Aquatic Resources, Section for Aquaculture
Authors: Bruun, M. S. (Intern), Pedersen, L. (Intern), Dalsgaard, I. (Intern), Pedersen, P. B. (Intern), Sortkjær, O. (Ekstern)
Pages: 57-61
Publication date: 2007
Tingkærsvad Dambrug - et modeldambrug under forsøgsordningen: Statusrapport for 1. måleår af monitoringsprojektet

General information
State: Published
Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Svendsen, L. (Ekstern), Sortkjær, O. (Ekstern), Bering Ovesen, N. (Ekstern), Skriver, J. (Ekstern), Larsen, S. (Ekstern), Pedersen, P. B. (Intern), Rasmussen, R. S. (Intern), Dalsgaard, A. J. T. (Intern)
Number of pages: 53
Publication date: 2007

Publication information
Place of publication: Hirtshals
Publisher: Danmarks Fiskeriundersøgelser
Original language: Danish
Series: DFU-rapport
Number: 173-07
Main Research Area: Technical/natural sciences
Electronic versions:
173-07, elektronisk_index.pdf
Links:
Source: orbit
Source-ID: 227607
Publication: Research › Report – Annual report year: 2007

90 millioner kr. skal klargøre danske dambrugeres fremtid: Otte dambrug er med i spændende og næsten altafgørende forsøgsprojekt

General information
State: Published
Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Pedersen, P. B. (Intern)
Pages: 2-3
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: Ferskvandsfiskeribladet
Volume: 103
Issue number: 6
ISSN (Print): 0015-0223
Ratings:
ISI indexed (2013): ISI indexed no
ISI indexed (2012): ISI indexed no

General information
State: Published
Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: EFSA Publication
Number of pages: 75
Publication date: 2006

Publication information
Place of publication: Copenhagen, Denmark
Publisher: Ministry of Foreing Affairs, DANIDA
Original language: English
Main Research Area: Technical/natural sciences
Links:
http://www.niaslin.dk/gateway_to_asia/nordic_webpublications/x506033405.pdf

Bibliographical note
Ref. no. 104, BANG 805-200
Source: orbit
Source-ID: 260300
Publication: Research › Report – Annual report year: 2006

Dose-dependent decomposition rate constants of hydrogen peroxide in small-scale biofilters

General information
State: Published
Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Pedersen, L. (Intern), Pedersen, P. B. (Intern), Sortkjær, O. (Ekstern)
Pages: 8-15
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: Aquacultural Engineering
Volume: 34
Issue number: 1
ISSN (Print): 0144-8609
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.09 SJR 0.798 SNIP 1.525
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.723 SNIP 1.148 CiteScore 1.63
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.72 SNIP 1.437 CiteScore 1.61
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.666 SNIP 1.511 CiteScore 1.8
Ejstrupholm Dambrug - et modeldambrug under forsøgsordningen. Statusrapport for første måleår af moniteringsprojektet

General information
State: Published
Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Svendsen, L. (Ekstern), Sortkjær, O. (Ekstern), Ovesen, N. (Ekstern), Skriver, J. (Ekstern), Larsen, S. (Ekstern), Pedersen, P. B. (Intern), Rasmussen, R. S. (Intern), Dalsgaard, A. J. T. (Intern)
Number of pages: 54
Publication date: 2006

Publication information
Place of publication: Hirtshals
Publisher: Danmarks Fiskeriundersøgelser
ISBN (Print): 87-7481-024-3
Original language: Danish

Series: DFU-rapport
Number: 166-06
Main Research Area: Technical/natural sciences
Links:
http://www.difres.dk/dk/publication/files/18122006$166-06,%20elektronisk_index.pdf
Source: orbit
Source-ID: 227597
Publication: Research › Report – Annual report year: 2006
Opdræt af torskeyngel til udsætning i Østersøen, 01.02.2004-30.06.2004: Slutrapport

General information
State: Published
Organisations: Section for Coastal Ecology, National Institute of Aquatic Resources, Section for Aquaculture
Authors: Støttrup, J. (Intern), Overton, J. L. (Intern), Möllmann, C. (Ekstern), Paulsen, H. (Intern), Pedersen, P. B. (Intern), Lauesen, P. (Intern)
Number of pages: 77
Publication date: 2005

Publication information
Place of publication: Charlottenlund
Publisher: Danmarks Fiskerundersøgelser
ISBN (Print): 87-90968-72-7
Original language: Danish

The potential for enhancing the cod stock in the Eastern Baltic

General information
State: Published
Organisations: Section for Coastal Ecology, National Institute of Aquatic Resources, Section for Aquaculture, Section for Population- and Ecosystem Dynamics
Pages: 67-71
Publication date: 2005
Conference: Lessons from the past to optimise the future: Extended abstracts and short communications of contributions presented at the International Conference, Aquaculture Europe 2005, Trondheim, Norway, August 5-9, 01/01/2005
Main Research Area: Technical/natural sciences

Publication information
Journal: Special publication / European Aquaculture Society
Volume: 35
ISSN (Print): 0774-0689
Ratings:
Web of Science (2018): Indexed yes
ISI indexed (2013): ISI indexed no
ISI indexed (2012): ISI indexed no
ISI indexed (2011): ISI indexed no
**Dansk dambrug ved en skillevej**

**General information**
State: Published
Organisations: Institute Management, National Institute of Aquatic Resources, Section for Aquaculture
Authors: Thomsen, H. A. (Intern), Pedersen, P. B. (Intern), Pedersen, L. (Intern)
Pages: 4-17
Publication date: 2004
Main Research Area: Technical/natural sciences

**Publication information**
Journal: Fisk og Hav
Issue number: 58
ISSN (Print): 0105-9211
Ratings:
ISI indexed (2013): ISI indexed no
ISI indexed (2012): ISI indexed no
ISI indexed (2011): ISI indexed no
Original language: Danish
Links:
Source: orbit
Source-ID: 227570
Publication: Research › Conference article – Annual report year: 2005

**En hjælpende hånd til torsk i Østersøen**

**General information**
State: Published
Organisations: Section for Coastal Ecology, National Institute of Aquatic Resources, Section for Population- and Ecosystem Dynamics, Section for Aquaculture, Technical University of Denmark
Authors: Støttrup, J. (Intern), Tomkiewicz, J. (Intern), Paulsen, H. (Intern), Pedersen, P. B. (Intern), Overton, J. L. (Intern), Möllmann, C. (Ekstern), Lauesen, P. (Intern)
Pages: 62-71
Publication date: 2004
Main Research Area: Technical/natural sciences

**Publication information**
Journal: Fisk og Hav
Issue number: 58
ISSN (Print): 0105-9211
Ratings:
ISI indexed (2013): ISI indexed no
ISI indexed (2012): ISI indexed no
ISI indexed (2011): ISI indexed no
Original language: Danish
Links:
Source: orbit
Source-ID: 227656
Publication: Research › Journal article – Annual report year: 2004

**En undersøgelse af muligheder for etablering af måleprogram på såkaldte modeldambrug**

**General information**
State: Published
Organisations: Section for Aquaculture, National Institute of Aquatic Resources

**Publication information**
Journal: Fisk og Hav
Issue number: 58
ISSN (Print): 0105-9211
Ratings:
ISI indexed (2013): ISI indexed no
ISI indexed (2012): ISI indexed no
ISI indexed (2011): ISI indexed no
Original language: Danish
Links:
Source: orbit
Source-ID: 227541
Publication: Research › Journal article – Annual report year: 2004
Det kommercielle grundlag for nye opdrætsformer i marin akvakultur i Danmark

General information
State: Published
Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Pedersen, P. B. (Intern)
Publication date: 2003

Host publication information
Title of host publication: Udvalget vedr. udviklingsmulighederne for saltvandsbaseret fiskeopdræt i Danmark
Place of publication: København
Publisher: Ministeriet for Fødevarer, Landbrug og Fiskeri
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 227087
Publication: Research › Book chapter – Annual report year: 2003

Dietary lipid level for gilthead sea bream - effects on apparent digestibility, growth, protein retention and proximate composition

General information
State: Published
Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Ekmann, K. S. (Intern), Holm, J. (Ekstern), Pedersen, P. B. (Intern)
Publication date: 2003
Event: Poster session presented at International Symposium on Nutrition and Feeding in Fish, Rhodes, Greece.
Main Research Area: Technical/natural sciences

Bibliographical note
Poster presentation and abstract
Source: orbit
Source-ID: 314636
Publication: Research › Poster – Annual report year: 2003

Modeldambrug: Specifikationer og godkendelseskrav: Rapport fra faglig arbejdsgruppe

General information
State: Published
Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Pedersen, P. B. (Intern), Grønborg, O. (Ekstern), Svendsen, L. (Ekstern)
Number of pages: 84
Publication date: 2003
Genetic variation for growth rate, feed conversion efficiency, and disease resistance exists within a farmed population of rainbow trout

The objective of this study was to test that additive genetic (co)variation for survival, growth rate, feed conversion efficiency, and resistance to viral haemorrhagic septicaemia (VHS) exists within a farmed population of rainbow trout. Thirty sires and 30 dams were mated by a partly factorial mating design. Each sire was mated to two dams, and each dam was mated to two sires, producing 50 viable full-sib families (29 sires, 25 dams). The fish from these families were reared for a 215-day growout period, and were assessed for survival between days 52 and 215, growth rate (i.e., body weight on days 52, 76, 96, 123, 157, 185, and 215, and body length on days 52 and 215); feed conversion efficiency between days 52-215, 52-76, 77-96, 97-123, 124-157, 158-185, and 186-215, and VHS resistance. REML estimates of additive genetic variation for the body weights, body lengths, and feed conversion efficiencies were obtained by fitting univariate linear (reduced) animal models. Additive genetic variation for VHS resistance was estimated by fitting a Weibull, sire-dam frailty model to time until death of fish challenged with VHS. Genetic correlations were estimated among the body weights, body length, and feed conversion efficiencies that expressed additive genetic variation, while genetic correlations between VHS resistance and the body weights, body length, and feed conversion efficiencies were approximated as product-moment correlations among predicted breeding values of the sires and dams. Additive genetic variation was found to be very low for survival, body weight on days 52 and 76, body length on day 52, and feed conversion efficiency between days 185 and 215. However, additive genetic variation was detected for body weight on days 96, 123, 157, 185, and 215 (coefficient of additive genetic variation (CV)=8.4-28.4%, heritability (h2)=0.35 for body weight on day 215), body length on day 215 (CV=6.9%, h2=0.53), feed conversion efficiency between days 52-215, 52-76, 77-96, 97-123, 124-157, and 158-185 (CV=4.0-13.9%), and VHS resistance (additive genetic variance for log-frailty=0.24, h2 on the logarithmic-time scale=0.13). Genetic correlations among the body weights, body length, and feed conversion efficiencies that expressed additive genetic variation were generally favourable and moderate-to-very strong (0.55-0.99), though there were unfavourable correlations (-0.01 to -0.33) between the predicted breeding values for VHS resistance and the predicted breeding values for the body weights, body length, and feed conversion efficiencies. These results demonstrate that additive genetic (co)variation for growth rate, feed conversion efficiency, and VHS resistance does exist within the farmed population of rainbow trout, and indicates that selective breeding for these traits can be successful.
Use of hydrodynamic and benthic models for managing environmental impacts of marine aquaculture

Regulation to minimize impacts from aquaculture is of key concern in coastal zone management for the sustainability of the industry and the receiving environment. Market and consumer forces are presently driving much of this regulation and its implementation. Mathematical modelling can provide the tools for planning and monitoring as well as regulation, and a number of countries have well-developed policies and procedures in place which utilize modelling tools. The main impacts currently modelled are nutrient enhancement, organic waste deposition and the dispersion and deposition of medicines and chemicals. The release of these wastes is influenced by species- and site-specific characteristics, as well as culture and husbandry techniques. The modelling process requires consideration of definitions and limitations; standards for model development including clear objectives and justification; good technical descriptions use of good and appropriate data; calibration; validation; sensitivity analysis; quality assurance; auditability and consideration of the operational needs of the user, the grower and/or the regulator. Models should have simplicity and clarity; be fit for purpose, be open to scrutiny; be accessible, user-friendly and be used with caution. Current models are considered to be limited in scope but do cover the main hydrodynamic and particulate processes. The regulation and monitoring of finfish aquaculture involving the direct use of models is apparently restricted to relatively few countries where they are involved in setting holding capacity, the licensing of medicines and for assessing site applications. Different approaches have been developed in different countries as required. In contrast, many countries do make considerable indirect use of modelling techniques within the regulation process. With respect to shellfish, models are in current use to predict and optimize exploitation capacity but there is scope for studying nutrient flux, habitat degradation and deposition below suspended systems. Future developments for finfish need to better address the main question of holding capacity or exploitation capacity in relation to nutrients and medicines release, including whole water body/regional impacts. The relationship and predictability of toxic algal blooms remains some way off. Modelling the complexities of degradation, resuspension and the effect of the scavenging process on the transport of in-feed medicines is required. Keys to future developments across Europe include accessibility, setting of Environmental Quality Standards or targets, training and support for users, resources and structured research.
Monitoring and regulation of marine aquaculture in Denmark

General information
State: Published
Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Pedersen, P. B. (Intern)
Pages: 144-148
Publication date: 2000
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Applied Ichthyology-Zeitschrift für Angewandte Ichthyologie
Volume: 16
Issue number: 4-5
ISSN (Print): 0175-8659
Ratings:
BFI (2018): BFI-level 1
Optimal ratio between digestible protein and digestible energy in feed for European sea bass (Dicentrarchus labrax)

General information
State: Published
Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Pedersen, P. B. (Intern), Lund, I. (Intern), Holm, J. (Ekstern), Boisen, S. (Ekstern), Hjermitslev, N. (Ekstern), Autin, M. (Ekstern), Jokumsen, A. (Intern)
Publication date: 2000

Host publication information
Title of host publication: Book of Abstracts
Main Research Area: Technical/natural sciences
Conference: Aqua 2000, Nice, France, 01/01/2000
Source: orbit
Source-ID: 260318
Publication: Research › Conference abstract in proceedings – Annual report year: 2000

Undersøgelse af eventuelle miljøpåvirkninger af hjælpestoffer og medicin i ferskvandsdambrug samt metoder til at reducere/eliminere sådanne påvirkninger

General information
State: Published
Assistance to assess a draft regulation of the aquaculture sector in Mozambique

General information
State: Published
Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Pedersen, P. B. (Intern)
Number of pages: 34
Publication date: 1999

Publication information
Place of publication: Copenhagen
Publisher: DANIDA
Original language: English
Series: DANIDA - Rapport
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 227086
Publication: Research › Report – Annual report year: 1999

Foderrapport 1-5

General information
State: Published
Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Pedersen, P. B. (Intern)
Publication date: 1999

Publication information
Place of publication: Hirtshals
Publisher: Danmarks Fiskeriundersøgelser
Original language: Danish
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 227089
Publication: Research › Report – Annual report year: 1999

Vedrørende udvikling af en mærkningsmodel for økologisk akvakulturproduktion

General information
State: Published
Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Pedersen, P. B. (Intern)
Eel culture trends in Europe

General information
State: Published
Organisations: Unknown
Authors: Pedersen, P. B. (Intern)
Pages: 35-37
Publication date: 1998
Main Research Area: Technical/natural sciences

Publication information
Journal: Fisheries Bulletin
Issue number: 17
ISSN (Print): 0332-4338
Ratings:
Web of Science (2018): Indexed yes
ISI indexed (2013): ISI indexed no
ISI indexed (2012): ISI indexed no
ISI indexed (2011): ISI indexed no
Original language: English

Bibliographical note
Source: orbit
Source-ID: 260320
Publication: Research - peer-review › Journal article – Annual report year: 1998

Status on recirculation technology in Denmark

General information
State: Published
Organisations: Section for Aquaculture, National Institute of Aquatic Resources
Authors: Pedersen, P. B. (Intern)
Pages: 1-6
Publication date: 1998
Main Research Area: Technical/natural sciences

Publication information
Journal: ICES C.M. 1998/
Volume: L:8
Original language: English
Source: orbit
Source-ID: 227097
A multidisciplinary Danish research program on rainbow trout (Oncorhynchus mykiss) farming

A new research programme involving eight Danish institutions is described. The programme started in 1993 and is expected to run for 5 years. The primary objective of the research initiative is to exploit and integrate the knowledge of several institutions and disciplines for the benefit of the production of rainbow trout. The programme includes several projects with aspects of disease prevention, genetics, and nutrition. In most of the projects, the work has been divided into stages of 2 and 3 years, respectively. During a 2 year period, production, management and health status are recorded at the participating fish farms, and all data are organized in a database. Diseases cause major problems in rainbow trout production, therefore a great deal of the effort in this programme deals with diseases caused by virus, bacteria and parasites. On the basis of the database, epidemiological examinations are carried out as well as investigations of the possibilities of preventive measures and cost-benefit analyses. In the genetic studies, polymorphic genetic markers will be developed and used for analysis of the genetic structure of selected fish stocks. Microsatellites will be developed and introduced in the study. Primarily genetic differences between lines/strains and their crossings will be estimated with the purpose of describing the genetic level and the importance of additive and non-additive genetic effects. In the nutritional area the product quality and pollution questions will be in focus.
Feed intake in Sea bass and Sea bream in relation to body weight, temperature and feed pellet size

General information
State: Published
Organisations: Unknown
Authors: Talbot, C. (Ekstern), Rosenlund, G. (Ekstern), Pedersen, P. B. (Intern)
Publication date: 1995
Event: Poster session presented at Aquaculture Europe '95 : 9-12 August, Trondheim, Norway, .
Main Research Area: Technical/natural sciences
Source: orbit
A multi-disciplinary Danish research programme on rainbow trout (Oncorhynchus mykiss) farming.

General information
State: Published
Organisations: Section of Fish Diseases, Division of Poultry, Fish and Fur Animals, National Veterinary Institute, Section for Fish Diseases, National Institute of Aquatic Resources, Section for Aquaculture
Authors: Berg, P. (Ekstern), Eggum, B. (Ekstern), Møller, S. (Ekstern), Holm, L. (Ekstern), Jørgensen, P. (Ekstern), Olesen, N. J. (Intern), Buchmann, K. (Intern), Larsen, J. (Ekstern), Dalsgaard, I. (Intern), Mellergaard, S. (Intern), From, J. (Ekstern), Frier, J. (Ekstern), McLean, E. (Ekstern), Hørlyck, V. (Intern), Graver, C. (Intern), Kristensen, T. (Ekstern), Birk, E. (Ekstern), Pedersen, P. B. (Intern)
Publication date: 1994
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 241591
Publication: Research › Conference abstract for conference – Annual report year: 1994

Chitosan i fiskefoder

General information
State: Published
Organisations: Danish Institute for Fisheries and Marine Research
Authors: Pedersen, P. B. (Intern)
Number of pages: 49
Publication date: 1993

Publication information
Place of publication: København
Publisher: Miljøstyrelsen
Original language: Danish
Series: Arbejdsrapport fra Miljøstyrelsen
Number: 36
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 260324
Publication: Research › Report – Annual report year: 1993

Projects:

Micro particles in Aquaculture: cause and effects and ways to remove them

National Institute of Aquatic Resources
Period: 15/01/2017 → 14/01/2020
Number of participants: 4
Phd Student: de Jesus Gregersen, Joao (Intern)
Supervisor: Pedersen, Per Bovbjerg (Intern)
Pedersen, Lars-Flemming (Intern)
Main Supervisor: Dalsgaard, Anne Johanne Tang (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Design and operation optimization of constructed wetlands at rainbow trout farms (39430)

This project aims at improving the design and operation of constructed wetlands with respect to the removal of waste nutrients and organic matter deriving from model trout farm systems type I and III.

The project contains five work packages:
1. Selection of representative fish farms to be part of a user group and where testing and measurements will be carried out
2. Mapping and characterization of selected wetlands
3. Measuring the effects of flow velocity, water column depth, and hydraulic retention time on the removal of nutrients and organic matter
4. Data analysis
5. Project management, administration and dissemination of results.

The project is funded by Ministry of Environment and Food of Denmark and the European Maritime and Fisheries Fund (EMFF)

National Institute of Aquatic Resources
Section for Aquaculture
Danish Aquaculture Association
Period: 06/10/2016 → 11/01/2019
Number of participants: 3
Research area: Aquaculture
Project participant:
Pedersen, Per Bovbjerg (Intern)
Dalsgaard, Anne Johanne Tang (Intern)
von Ahnen, Mathis (Intern)

Development of an electrochemical method to remove nitrate in RAS (Electro-nitrate) (39327)

This project is done in collaboration with two industrial partners, testing the nitrate removal potential of an innovative technique applied to aquaculture.

Nitrate is a dissolved N-waste product from fish production in recirculating aquaculture systems (RAS). The amount and concentration of nitrate in the effluent are determined by the daily feeding, biological filtration and the feed loading (kg feed pr. m³ water exchange) among others.

Discharged nitrate is a main factor affecting the recipient hence important to reduce in order to obtain sustainable production in RAS.

As an alternative to denitrification, electrochemical reduction of nitrate to N₂ is considered in this project. Electrochemical water treatment rely on physio-chemically controlled redox processes that includes a flow cell with two electrodes connected to an external current source This aim of this project is preliminary test and screening of different types of electrode material and combinations and investigate factors affecting removal capacity. The effect of current density, flow rates, substrate concentrations and pH on nitrate removal will be tested and removal capacity will be evaluated.

This project is coordinated by DHI.

The project is funded by Innovation Network for Environmental Technologies (Inno-MT), Danish Agency for Science, Technology and Innovation.

National Institute of Aquatic Resources
Section for Aquaculture
DHI Denmark
Aquapri
Electrocell
Period: 01/02/2016 → 31/12/2016
Number of participants: 2
Research area: Aquaculture
**Project participant:**
- Pedersen, Lars-Flemming (Intern)
- Pedersen, Per Bovbjerg (Intern)

**Project**

**Efficient and innovative fish production via best available technology (RAS2020) (39328)**

This project includes a full scale test and development of a conceptual recirculating aquaculture system (RAS) for king fish production. The innovative aspect of this modular RAS2020 concept regards the design—a one unit circular module designed to have a 1200 MT/Y capacity.

The aim of this project is to build and develop a RAS unit with small footprint, low cost and reduced construction time. The RAS2020 unit includes state of the art treatment units (Hydrotech drumfilters, Krüeger biofilters—nitrification and denitrification) and is built with flexible interconnected rearing sections. When the RAS2020 is built and stocked with kingfish, an extended sampling and monitoring program will be performed in order to assess system performance in particular N, P and organic matter removal.

This project is coordinated by Sashimi Royal.

The project is funded by the Danish Environmental Protection Agency.

National Institute of Aquatic Resources
Section for Aquaculture
Sashimi Royal
Aqua-Partners Aps
Dansk Akvakultur

**Period:** 01/02/2016 → 31/12/2018
**Number of participants:** 7
**Research area:** Aquaculture

**Project participant:**
- Pedersen, Lars-Flemming (Intern)
- Pedersen, Per Bovbjerg (Intern)
- Jokumsen, Alfred (Intern)
- Møller, Brian (Intern)
- Sproegel, Ulla (Intern)
- Frandsen, Dorthe (Intern)
- Nielsen, Sara Møller (Intern)

**Project**

**Environmental neutral aquaculture water treatment (MIVANAK) (39295)**

Despite a transition from flow-through systems to more advanced open water reuse aquaculture systems (e.g. model trout farms), the need for water treatment still exists. In brackish and saltwater reuse systems, blooms of toxic microalgae in an example of a recently new challenge.

The purpose of this project is to further develop current aquaculture water treatment practice and reduce the total amount of disinfectants used.

The project includes 3 different work packages, investigating
- ecological consequences of continuous application of peroxyacetid acid.
- toxicological effects of easy degradable disinfectants.
- alternative biological methods to control / avoid blooms of toxic heterotrophic dinoflaggelates.

Trials will include mesocosmos experiments where disinfectants are added continuously or by daily pulses over a prolonged period of time where phyto- and zoo-plankton abundance and compositions will be investigated. Other trials will be made in batch experiments with pure algae cultures, as will prolonged continuous peroxyacid application experiments be made.

This project is coordinated by DTU Aqua.

The project is funded by the Environmental Protection Agency's Programme for Pesticide Research.
Water treatment technology for microbial stabilization in landbased aquaculture systems (MicStaTech) (39277)

MicStaTech is a transnational research project (COFASP) between Norwegian, German and Danish research groups. The paradigm of this project is that a stable, elevated microbial abundance in the water phase of land based aquaculture systems can be beneficial for fish health and economically profitable. A common challenge in land based systems, and shown across species, is the loss of fish due to unfavourable conditions and disease outbreaks that may be linked to opportunistic bacteria. A popular approach to prevent this is to attempt to reduce the load of bacteria in the systems by the use of UV, ozone or chemical disinfection. This is however not possible or sufficient in the majority of systems, because disinfection has a non-lasting effect on the numbers and a destabilising effect on the composition of bacteria. In most systems, the water exchange rates and organic loading applied for biological reasons allow for microbial regrowth in the rearing tanks. Hence, alternative approaches to reduce the chances of disease outbreaks are needed. This project pursues the concept of establishing and maintaining stable microbial systems.

Water treatment technology for promoting K-selection, which is a selective pressure disfavouring the r-selected opportunists, has shown very promising results for several marine species in small scale experiments, but the up-scaling and optimization for flow through systems (FTS) and recirculating aquaculture systems (RAS) remains. The paradigm favouring a stable and elevated bacterial abundance is foreseen to reduce fish mortality and also reduce water treatment costs. This project will investigate fish health and microbial carrying capacity in experiments performed at three locations – NTNU, DTU Aqua and University of Applied Sciences, Saarlandes, Germany.

This project is coordinated by Norwegian University of Science and Technology, Norway.

The project is funded by EU, COFASP, ERA-NET.

National Institute of Aquatic Resources

Section for Aquaculture

Norwegian University of Science and Technology

Hochschule für Technik und Wirtschaft des Saarlandes University of Applied Sciences

Period: 01/03/2015 → 31/12/2017

Number of participants: 7

Research area: Aquaculture

Project participant:

Pedersen, Per Bovbjerg (Intern)
Rojas-Tirado, Paula Andrea (Intern)
Sproegel, Ulla (Intern)
Frandsen, Dorthe (Intern)
Møller, Brian (Intern)
Nielsen, Sara Møller (Intern)

Project Manager, academic:

Pedersen, Lars-Flemming (Intern)
Project Microbial Water Quality within Aquaculture Recirculation Systems

National Institute of Aquatic Resources
Period: 01/12/2014 → 30/11/2017
Number of participants: 6
PhD Student: Rojas-Tirado, Paula Andrea (Intern)
Supervisor: Pedersen, Per Bovbjerg (Intern)
Main Supervisor: Pedersen, Lars-Flemming (Intern)
Examiner: Dalsgaard, Anne Johanne Tang (Intern)
Attramadal, Kari (Ekstern)
Verdegem, Marc (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

Cost efficient solutions for reducing the waste discharged in land-based marine recirculating aquaculture systems (WASTE-TREAT) (39190)
Growth in aquaculture production demands a high degree of environmental engineering to minimize nutrient discharge thereby reducing the environmental impact. This industrial collaboration project aims at finding the cost-efficient treatment methods for reducing the waste discharged from large-scale land-based marine recirculating aquaculture systems. End-of-pipe solutions for minimizing the N, P, and organic matter waste discharge from seawater RAS are to be developed, demonstrated and evaluated.

The project is coordinated by AKVA Group Denmark A/S.

The project is funded by the Danish Ministry of Food, Agriculture and Fisheries through the Green Development and Demonstration Program (GUDP).

National Institute of Aquatic Resources
Section for Aquaculture
AKVA Group Denmark A/S

Danish Salmon A/S
Period: 15/08/2014 → 01/09/2017
Number of participants: 3
Research area: Aquaculture
Project participant: Fernandes, Paulo (Intern)
Project Manager, academic: Letelier-Gordo, Carlos Octavio (Intern)
Pedersen, Per Bovbjerg (Intern)

Fluorescence analysis and monitoring of recirculating aquaculture systems (FAMoRAS) (39177)
FAMoRAS aimed to investigate fluorescence spectroscopy for potential utilization within 3 main areas of recirculating aquaculture system operation:
(1) system "health" monitoring
(2) treatment performance
(3) feed utilization.

Using sensitive lab-scale spectroscopic analysis and mathematical modeling, the project aimed to identify single wavelengths for future use as online, in-situ aquaculture system sensors.

This project was coordinated by DTU Aqua.
Towards stable water quality in RAS by use of a new rapid microbial test (Biostable water) (39154)

Water quality control is central for successful management of recirculating aquaculture systems. Most common and important chemical parameters (i.e. pH, TAN, nitrite, alkalinity) are measurable, whereas microbial water quality (abundance and activity) is more complicated to measure. Microbial water quality measurements are important for several reasons: it can be used to ensure safe and stable conditions (baseline), to identify sudden changes (deviations from baseline) and potentially contribute to improve system performance by identifying suboptimal treatment component or practices.

The aim of this project is to test a rapid microbial methods developed by Mycometer; a test that quantifies the microbial activity in different types of water samples within 30 minutes from sampling to measurement. The Bactiquant® method is expected to provide new insight of microbial succession within RAS and will be used to monitor microbial water quality in commercial recirculating aquaculture systems.

The project includes controlled batch experiments where disinfection efficiency and regrowth potentials can be estimated. The new knowledge can be applied in RAS management, and the project also includes method verification under commercial RAS conditions. The equipment has been introduced and implemented on a large model trout 3 farm with mixed effect and valuable experiences. The method is also being introduced to a huge smolt RAS facility build by Billund Aqua; here daily monitoring as well as intensive campaigns including diurnal measurements will be performed.

The project is coordinated by DTU Aqua.

The project is funded by the Danish Ministry of Food, Agriculture and Fisheries through the Green Development and Demonstration Program (GUDP).

National Institute of Aquatic Resources

Section for Aquaculture

Mycometer A/S

Billund Aquaculture Service Aps

Period: 01/02/2014 → 01/07/2016

Number of participants: 9

Research area: Aquaculture

Project participant:

Rojas-Tirado, Paula Andrea (Intern)
Pedersen, Per Bovbjerg (Intern)
Spreegel, Ulla (Intern)
Møller, Brian (Intern)
Nielsen, Sara Møller (Intern)
Frandsen, Dorthe (Intern)
Larsen, Ole Madvig (Intern)
Jensen, Rasmus Frydenlund (Intern)

Project Coordinator:

Pedersen, Lars-Flemming (Intern)

Project
Network towards phasing out formalin in aquaculture (39140)

Formalin is still used in large quantities in aquaculture systems despite unwanted side-effects and efforts to reduce the amount used. Apparently the need for water treatment increases with shift from flow-through to RAS. This project established a network of fish farmers (8 persons representing different systems), three national fish-vets covering >95% of Danish fish farms, DTU Aqua researchers and Danish Aquaculture organization. The common goal was to identify methods to cease the aquaculture related use of formalin. Recent knowledge, new techniques and practical experience with alternative disinfectants (e.g. hydrogen peroxide or peracetic acid) were applied and tested. In particular, distribution, degradation and automatic dosage of Peracetic acid by digital pumps was analytically verified. The project tested and developed better water treatment protocols for different types of rearing systems (hatcheries and grow out production systems, flow-through, model trout farms to fully recirculated systems) in close collaboration between fish-vets, fish farmers and DTU Aqua. Results from monitoring on a number of fish farms and experience over 2 seasons were obtained and the new practically applied knowledge/information was presented at workshops/seminars with the aquaculture industry as well as reported in a Danish report (Danish Aquaculture 2015-10). A number of veterinarians and fish farms were partners in the project. The project was coordinated by Danish Aquaculture Association. The project was funded by the Danish Ministry og Food, Agrirculture and Fisheries and the European Fisheries Fund (EFF).

National Institute of Aquatic Resources
Section for Aquaculture
Period: 01/12/2013 → 01/05/2015
Number of participants: 4
Research area: Aquaculture
Project participant:
Pedersen, Lars-Flemming (Intern)
Pedersen, Per Bovbjerg (Intern)
Sproegel, Ulla (Intern)
Møller, Brian (Intern)

Development of educational opportunities for Danish aquaculture (39157)

Danish aquaculture systems have faced substantial changes during the recent years, which have necessitated further education and practical implementation of new knowledge.

This project was initiated by Danish Aquaculture Organization (DAO). Based on an increasing demand for improved and updated education/training to people in the aquaculture industry, DAO identified various initiatives to develop educational for Danish aquaculture. Key players within the aquaculture sector were identified to support these initiatives.

The outcome of the project was
- Initiation and implementation of a new education at Hansenberg in Kolding, (www.hansenberg.dk) ,
- Participation in developing the courses for aquaculture trainees (practical/theoretical exercises),
- Production of advertising material (posters, pamphlets) promoting the education and aquaculture in general,
- Production of the first public available E-book (“Aquaculture”: 14 chapters, 360 pp.) (http://www.danskakvakultur.dk/uddannelse/e-bog/)

This project was coordinated by the Danish Aquaculture Organization.

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
Danish Aquaculture Organisation
University of Copenhagen
Aarhus University
Seges Knowledge Centre for Agriculture
**Environmentally effective nitrogen removal in fish farming using sludge hydrolysis (wiN-wiN) (39119)**

Reducing nitrogen discharge is important to fish farms and their environmental performance. Removal of nitrogen can be done by applying denitrification filters end-of-pipe (i.e. before discharge) through an anerobic de-nitrification process using organic carbon as energy source.

Using external carbon is costly and introduces additional organic matter into the system. In contrast, sludge produced by the farmed fish might provide the organic matter given that a hydrolysis process can be controlled and optimised according to the needs of the denitrification process.

The project strives to establish, optimize and demonstrate an integrated system in commercial scale able to hydrolyse generated sludge and subsequently use it as energy source for nitrogen removal in end-of-pipe denitrification filters.

This project is coordinated by HME, Denmark.

The project is funded by the Danish Ministry of Food, Agriculture and Fisheries through the Green Development and Demonstration Program (GUDP) and the partners involved.

National Institute of Aquatic Resources
Section for Aquaculture
HME
Lundby Dambrug
Period: 01/08/2013 → 31/12/2016
Number of participants: 4
Research area: Aquaculture
Project participant:
von Ahnen, Mathis (Intern)
Dalsgaard, Anne Johanne Tang (Intern)
Phd Student:
Letelier-Gordo, Carlos Octavio (Intern)
Project Manager, academic:
Pedersen, Per Bovbjerg (Intern)

**Optimized sludge hydrolysis and improved nitrogen removal through denitrification**

National Institute of Aquatic Resources
Period: 15/04/2013 → 15/03/2017
Number of participants: 7
Phd Student:
Letelier-Gordo, Carlos Octavio (Intern)
Supervisor:
Dalsgaard, Anne Johanne Tang (Intern)
Main Supervisor:
Pedersen, Per Bovbjerg (Intern)
Examiner:
Lund, Ivar (Intern)
Lund, Ivar (Intern)
von Rijn, Jaap (Ekstern)
von Rijn, Jaap (Ekstern)
New approaches and methods to improve the removal of dissolved nutrients in aquaculture

National Institute of Aquatic Resources
Period: 01/04/2013 → 30/06/2016
Number of participants: 6
Phd Student:
von Ahnen, Mathis (Intern)
Supervisor:
Pedersen, Per Bovbjerg (Intern)
Main Supervisor:
Dalsgaard, Anne Johanne Tang (Intern)
Examiner:
Jokumsen, Alfred (Intern)
Healy, Mark Gerard (Ekstern)
Schulz, Carsten (Ekstern)

Sustainable technologies to control microalgae in land based saltwater recirculating systems (39032)

Land based salt water recirculating systems is a potential alternative to fish farming in net pens. This purpose of this project was to test different solutions on how to control unwanted microalgae growth thereby addressing a potential challenges associated with land based farming.

A high degree of water reuse and the associated nutrient accumulation may favour growth of microorganisms and thereby deteriorate the biological water quality.

The project included:
- Test of improved mechanical filtration (application of pilot scale protein skimmers on small to medium sized RAS, and application of full scale 4 meter vacuum airlift; an innovative treatment technique tested in full scale RAS)
- Test of chemical water treatment routines using easy degradable disinfectants (Peracetic acid, chloramine-T, hydrogen peroxide) to control and inhibit toxic microalgae,
- Test of electrochemical oxidation disinfection technology to assess the efficacy (radical formation and algicidal effects) of boron doped diamond electrodes.

Numerous batch and pilot scale experiments were made at the section for Aquaculture, Hirtshals. In addition, intensive, diurnal sampling/monitoring and analysis on location was performed on a commercial pike perch RAS facilities facing toxic algae problems.

The project is coordinated by DTU Aqua.

The project was funded by the National Environmental Protection Agency through Programme for Development and Demonstration of Bio-technologies (MUDP).

National Institute of Aquatic Resources
Section for Aquaculture
University of Copenhagen
AquaPri Innovation
Billund Aquaculture Service Aps
Electrocell
Environmental Protection Agency
Period: 01/01/2013 → 30/11/2013
Number of participants: 8
Better use of nutrition resources for sustaining aquaculture production in Central Vietnam under climate change condition (SANSIV) (38975)

The main objective of the project is to contribute to the sustainable development of coastal aquaculture in Central Vietnam under climate change condition through better use of available nutrition resources. ARSINC (Aquaculture Research Sub-Institute for North Central (ARSINC), under Research Institute for Aquaculture) No.1 (RIA1) in Vietnam is the applicant and main responsible while DTU Aqua is the Danish partner. The immediate objectives of this project are:

- Better use of nutrition resources by developing cost-effective formulated feeds for permit (Trachinotus falcatus) and by application of non-feed based and improved integrated aquaculture models as adaptive practices in coping with the impacts of climate change in Central Vietnam.

- Propose and disseminate adapted aquaculture options to farmers, authorities and other stakeholders in response to climate change condition.

The project management and coordination have so far been in good status. Overall the project made appropriate progress toward achievement of the project's objectives. Reports on analysis of aquaculture system in Central region including Coastal farmer's livelihood and vulnerability to climate change were finalized. The reviews on known environmental effects of traditional diets for fish farming are on their final stage. Workshop on adaptive aquaculture techniques and models in response to climate change condition and proposed recommend policy was organized. These are served for proposing both adaptive aquaculture techniques/models and policies for local authorities. Through training course and study tour adaptive aquaculture techniques/models have been introduced to local farmers and extension workers.

Regarding to development of cost-effective grow-out pellet feed for these selected commercial carnivorous fish species - pompano (Trachinotus falcatus) as case study to replace trash fish to global limitation of fish meal and fish oil, all original planned experiments have completed. Additional experiments required for PhD student’s study will be carried out and finished within 2016. Experiments/trials on farming techniques for non-feed based species (hard shell clam Meretrix lyrata, macro alage Kappaphycus alvarezii) and integrated multi-tropic (shrimp and seaweed) have completed.

There have been 5 published articles, of which one article was published in an international peer review journal as the result of joint contribution between Vietnamese and Danish scientists.

All 3 MSC students from Aquaculture Research Sub-Institute for North Central (ARSINC-responsible institute) have finished their education through participation in project experiments by the end of 2015. These MSc staff will contribute to building research capacity and sustainability for ARSINC. Addition, one MSc student from Department of Science and Technology, Nghe An province, was also educated through participation in project experiments.

This project was coordinated by Aquaculture Research Sub-Institute for North Central, Research Institute for Aquaculture, Vietnam.

The project was funded by EU, Framework Programme 7.

National Institute of Aquatic Resources
Section for Aquaculture
Aalborg University
Period: 01/10/2012 → 01/10/2015
Number of participants: 3
Research area: Aquaculture
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

IT-solutions for environmental control of trout farms (39094)

In the project a IT-solution for direct reporting of environmental performance data from trout farms to the Municipality registration system was developed. Also, calculations of compliance with allowances etc. can be calculated and evaluated regularly by the farmer.

DTU Aqua further developed a discharge prediction model, able to calculate the resulting discharge from a ModelTroutFarm of any given layout and dimensions. This model (“Dambrugsmodellen” i.e. “the Trout Farm Model”) is based on the existing Produktionsbidragsmodel (“Waste Production Model”) and data and monitoring results from all treatment devices added and incorporated into a prediktive model. Both models are now widely used by the authorities as well as in the industry.

This project was coordinated by the Danish Aquaculture Association.

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
Danish Aquaculture Association
DHI Denmark
Aarhus University
Trout farms
Traditional trout farms (39095)
Nutrient removal is imperative for Danish fish farms and upcoming requirements for environmental performance though application of BAT (Best Available Technology) cannot be met by traditional fish farms since simple, low-cost technologies does not exist. Removal of dissolved nutrients in low concentrations and large water volumes is especially difficult.

In the project, potential low-cost technologies for removing nitrogen and organic matter were tested and documented. Removal and turn-over of organic matter and nitrogen in biofilters was studied, and the performance of constructed wetlands on traditional farms was also investigated during a full year. In these farms, wetlands efficiently remove particulate matter and associated nutrients (O and P) whereas dissolved matter is almost not removed due to the hydraulic load and short residence time. Depending on the concentrations in the incoming water, requirements for O and P net-removal could be met, whereas a need for simple, low-cost nitrogen removal was clearly demonstrated.

This project was coordinated by the Danish Aquaculture Association.

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

National Institute of Aquatic Resources
Section for Aquaculture
Danish Aquaculture Association

PhD in Recirculating Aquaculture Systems
National Institute of Aquatic Resources
Period: 01/04/2012 → 02/09/2015
Number of participants: 5
Phd Student: Fernandes, Paulo (Intern)
Main Supervisor: Pedersen, Per Bovbjerg (Intern)
Examiner: Dalsgaard, Anne Johanne Tang (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Eksternt finansieret virksomhed
Project: PhD
Aquaponics NOMA (Nordic Marine) – New innovations for sustainable aquaculture in the Nordic countries (38987)

A detailed study of the nutritional status of effluents from land-based fish farms as fertilizer for relevant plant species, adapt state-of-the-art technology and compare several aquaponic systems to meet the current and future challenges of both the aquaculture and horticulture industry, to develop commercial Aquaponics in the Nordic countries.

The project was coordinated by Bioforsk Øst, Landvik, Norway.

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

National Institute of Aquatic Resources
Section for Aquaculture
Norwegian Institute for Agricultural and Environmental Research
Norwegian Institute for Water Research
FB Aqua
Aquaponics AS
Hobas AS
Icelandic Food Research
Islensk Matorka ehf
Institute of Global Food and Farming
Government of Alberta
Leithbridge College
Period: 01/01/2012 → 01/01/2015
Number of participants: 3
Research area: Aquaculture
Project participant:
Paulsen, Helge (Intern)
Jokumsen, Alfred (Intern)
Pedersen, Per Bovbjerg (Intern)

Improved farming technology to optimize production, water quality and disease prevention in model trout farms (FOOP) (38950)

The aim of the project was to identify water quality parameters of significance to production traits and disease resistance in rainbow trout; specifically ammonia nitrogen, nitrite nitrogen, carbon dioxide, oxygen and nitrogen gas.

The project further aimed to pinpoint where in the model trout farm changes in water quality occurs. From these findings the project will attempt various rectifying actions to improve water quality. Finally, a series of experiments in collaboration with DTU Vet will clarify the importance of water quality parameters on disease resistance.

Examination of operational conditions at a number of different model trout farms showed that supersaturation with nitrogen gases was a chronic problem, and that dissolved CO2 levels were generally 2-3 fold higher than equilibrium conditions. Nitrogen supersaturation did however not occur at levels that negatively influenced production parameters (feed intake, feed conversion, and growth), however, CO2 levels were shown in laboratory experiments to negatively influence production at the observed levels. Ammonia and nitrogen levels were all within safe thresholds as verified by growth studies performed in the laboratory.

Fixed bed and moving bed biofilters each have their advantages and shortcomings. Hydraulic conditions in fixed bed biofilters caused a reduction in N turnover efficiency; however under laboratory conditions (optimal hydraulic conditions) fixed bed biofilters outperform moving bed. In site observations shown that fixed bed biofilters are also more resilient to variations in operational conditions, and are better at removing chemical therapeutants, possibly due to a higher load of organic material within the filter.

Biofilter performance was shown to be sensitive to both dissolved oxygen levels and alkalinity, but not at levels relevant for daily operation.

The project was coordinated by DTU Aqua.

This project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).
Model trout farms
Period: 01/10/2011 → 01/10/2013
Number of participants: 3
Research area: Aquaculture
Project participant:
Pedersen, Lars-Flemming (Intern)
Pedersen, Per Bovbjerg (Intern)
Project Coordinator:
Skov, Peter Vilhelm (Intern)

Best available technology applicable to traditional pond farms (38811)
As a consequence of environmental concerns – also following the Water Framework Directive legislations – traditional Danish pond farms need to install and operate (affordable) technology to reduce environmental impact from fish farming. In this project the best available technology applicable to traditional Danish flow-through pond farms was assessed and defined. Different technologies were installed/evaluated on selected farms and environmental effects were analysed, evaluated and discussed. Based on the study the best available technology and its applicability and effects on traditional farms was established, and the environmental authorities were supplied with details regarding what can realistically be done on this type of farms.
Nutrients (N & P) as well as organics, the pollutants most immediately relevant to the watercourse in such farms, were considered in the assessment.
The project was coordinated by Danish Aquaculture Association, Denmark.
The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).

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.
Innovative practices and technologies for developing sustainable aquaculture in the Baltic Sea region (AQUABEST) (38924)

In opposite to the global trend, aquaculture production in the Baltic Sea region had stagnated. It is widely accepted that aquaculture had great potential to feed the growing human population in the era of declining wild stocks ("Blue Revolution"), but new production has to be built on sustainable practices and technologies. The European Union has identified this challenge and has adopted aquaculture as a flagship project in the EU strategy for the Baltic Sea region.

Firstly, AQUABEST demonstrated that Baltic Sea region aquaculture was capable of becoming a nutrient neutral food production system. This was assessed to be achieved by replacing oceanic feed ingredients and plant products harvested at other continents with regional feed ingredients. Potential regional ingredients included Baltic Sea fish catches and Baltic Sea grown mussels not used for human consumption, as well as plant proteins and single cell proteins produced and processed in the region.

Secondly, AQUABEST adapted lessons from maritime spatial planning projects, developed them into guidelines and by regional testing demonstrated that spatial planning tools can be adapted to create environmentally, economically and socially sustainable aquaculture. Spatial planning activities were completed by activities that could support farmers to move fish cages offshore and which could support mussel farmers to adapt technologies that tolerated harsh winter conditions in the northern Baltic Sea.

New farming technologies using recirculating water have been developed especially in Denmark. The third solution of AQUABEST was to transfer these technologies to other regions and further develop them to adapt to brackish water conditions of the Baltic Sea. Furthermore, although recirculation farms already released much less nutrients in the effluent than conventional farms, nitrogen release of these farms could be further diminished. As the final outcome, AQUABEST carried out regional self-evaluation of current environmental regulation models in aquaculture. A novel ecosystem-based regulation needed new approach, environmental policy instruments and economic incentives. Concrete improvements were proposed after dialogue between major stakeholders.

The project was coordinated by Finish Game and Fisheries Research Institute, Finland.

The project was funded by EU, InterReg (regional collaboration).
Management and environmental improvement of recirculating aquaculture systems (38815)
The aim of this project was to identify new applicable measures and management strategies to optimize trout production in recirculating aquaculture systems (RAS), in particular the model trout farms. Model trout farms have gained lots of positive attention since their recent launch, as the rearing concept allows increased production, increased water reuse, and decreased nutrient discharge with obvious advantages for the natural fish fauna. Currently, model fish farms have generally experienced a certain fish mortality related to pathogens and suboptimal water quality. Scopes for improvement have been identified in terms of more focus on chemical and (micro-)biological water quality.

The project included four interrelated work packages:
1) Biological filtration (stable, optimal nitrification, nitrite accumulation issues, biofilter kinetics and management)
2) Denitrification: self-contained, operational end-of-pipe solution to reduce N-total from model trout farms
3) Water disinfection and sanitation: evaluation of UV systems disinfection efficacy, resulting water quality and test of easy degradable disinfectants to replace formalin
4) Gas saturation: consequences and effects of N super saturation and total gas pressure on fish performance in RAS.

Each WP addressed specific issues of concern based on current scientific knowledge and practical experience in dialogue with the aquaculture industry. The investigations included bench and pilot scale experiments conducted under controlled conditions at the research facilities at the Section for Aquaculture, DTU Aqua, Hirtshals. The project also included monitoring campaigns and experiments on commercial model trout farms in collaboration with stakeholders.

The project was coordinated by DTU Aqua.

The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).
Marine model trout farms (38816)
Based on the success with the development and implementation of Danish model trout farms in freshwater, a somewhat similar concept was developed for sea water farming of large trout and potentially also salmon in land-based, recirculating systems. Design and technology for the recirculation unit as well as for end-of-pipe treatment were developed and tested in 3 consecutive seasons.

During the project, design and operation were optimized and documented. End-of-pipe treatment, especially related to nitrogen removal and sludge hydrolysis were also investigated.

Based on the concept and the results achieved in the major unit in commercial scale at DTU Aqua premises in Hirtshals, it can be concluded that there is potential for such open land-based sea water farming units and that they can be operated commercially sustainable. Major issues related to reducing/preventing (toxic) algal blooms and supersaturation in seawater needs to be addressed before commercial operations should be initiated, though.

The project was coordinated by North Sea Science Park, Denmark.

The project was funded by the Danish Ministry of Food, Agriculture and Fisheries through the Green Development and Demonstration Program (GUDP) and the partners involved.

National Institute of Aquatic Resources
Section for Aquaculture
North Sea Science Park
BioMar A/S
AquaPri Innovation
Billund Aquaculture Service Aps
RK Plast A/S
Grundfos A/S
Period: 01/01/2011 → 31/12/2015
Number of participants: 4
Research area: Aquaculture
Project participant:
Letelier-Gordo, Carlos Octavio (Intern)
Pedersen, Lars-Flemming (Intern)
Project Manager, academic:
Pedersen, Per Bovbjerg (Intern)
Suhr, Karin Isabel (Intern)

Nordic network and conference on aquaculture recirculation technology (NordicRAS) (38842)
DTU Aqua has taken the initiative to establish a Nordic Network on Recirculating Aquaculture Technology (RAS). The idea is motivated by the facts that: (i) the geographical location and species composition requires certain breeding conditions and solutions, and (ii) the Nordic region has an excellent academic and commercial background for initiating such collaboration.

The purpose of the network is to strengthen Nordic research and research collaboration in RAS and associated water treatment including e.g. application of existing techniques in new setups, resolving potential new research areas, and investigating innovative operation forms that ensure high water quality. We anticipate that the network will become a continuous activity which could result in the establishment of consortiums that perhaps could apply for national and transnational European research funding, exchange of students, development of projects and potential educational programmes, etc.

The network is coordinated by DTU Aqua, and was founded at a steering committee meeting in April 2011 with country representatives from Denmark, Norway, Sweden, Finland and Iceland.

As one of its first activities, the network organises a RAS workshop in Helsinki on October 5-6, 2011. The aim of the workshop is to bring researchers and industrial partners with an interest in RAS together, creating a unique opportunity for
exchanging practical experiences and scientific knowledge on the newest developments in RAS. We anticipate that the workshop will become a recurrent event every other year in the country holding the presidency of the Nordic Council of Ministers.

National Institute of Aquatic Resources

Section for Aquaculture
Period: 01/01/2011 → ...
Number of participants: 2
Research area: Aquaculture

Project participant:
Pedersen, Per Bovbjerg (Intern)
Project Manager, academic:
Dalsgaard, Anne Johanne Tang (Intern)
Project

Nordic Network and Conference on Aquaculture Recirculation Technology (NordicRAS) (38842 & 39099 & 39223)

DTU Aqua has taken the initiative to establish a Nordic Network on Recirculating Aquaculture Technology (RAS). The idea is motivated by the facts that: (i) the geographical location and species composition requires certain breeding conditions and solutions, and (ii) the Nordic region has an excellent academic and commercial background for initiating such collaboration.

The purpose of the network is to strengthen Nordic research and research collaboration in RAS and associated water treatment including e.g. application of existing techniques in new setups, resolving potential new research areas, and investigating innovative operation forms that ensure high water quality. We anticipate that the network will become a continuous activity which could result in the establishment of consortiums that perhaps could apply for national and transnational European research funding, exchange of students, development of projects and potential educational programmes, etc.

The network is coordinated by DTU Aqua, and was founded at a steering committee meeting in April 2011 with country representatives from Denmark, Norway, Sweden, Finland and Iceland.

The main activity of the network will be to organise a RAS workshop every second year in one of the Nordic countries. The first workshop will be held in Helsinki (Finland), October 2011, the second workshop in Aalborg (Denmark) October 2013, and the third workshop in Molde (Norway) September - October 2015. The aim of the workshops is to bring researchers and industrial partners with an interest in RAS together, creating a unique opportunity for exchanging practical experiences and scientific knowledge on the newest developments in RAS.

This project is coordinated by DTU Aqua.

In 2011, the project was funded by AG-Fisk (Nordic Council of Ministers) and “Formandskabspuljen” (Nordic Council of Ministers). In 2012, follow-up activities and planning of future activities was funded by AG-Fisk. In 2013 and 2015 it was funded by AG-Fisk.

National Institute of Aquatic Resources

Section for Aquaculture
Period: 01/01/2011 → 31/12/2017
Number of participants: 2
Research area: Aquaculture

Project participant:
Pedersen, Per Bovbjerg (Intern)
Project Coordinator:
Dalsgaard, Anne Johanne Tang (Intern)
Project

Recirculation technology for future aquaculture (REFA) (38843)

An Innovation Consortia with many industrial partners. In the project, basic and applied research was performed by several partners to support the development of new and energy-efficient technologies for recirculation systems.

Some of the research issues were:
- to develop new filter technologies and energy-efficient aeration systems
- to develop process- and CFD models to improve our understanding and insight into dynamic variation in water quality parameters
- to determine the importance of particulate matter for biofilter operation (this was the DTU Aqua research package)
- to develop tools and instruments for advanced regulation and control of recirculating aquaculture systems
- to develop technologies for waste management
Twelve larger Danish companies were further partners in this project.

The project was coordinated by Danish Hydraulic Institute, Denmark.

The project was funded by the Danish Agency for Science, Technology and Innovation and the participating companies.

Department of Environmental Engineering
National Institute of Aquatic Resources
Section for Aquaculture
DHI Denmark
Aalborg University

Period: 01/01/2011 → 31/03/2015
Number of participants: 3
Research area: Aquaculture

Project participant:
Pedersen, Lars-Flemming (Intern)
Fernandes, Paulo (Intern)

Project Manager, academic:
Pedersen, Per Bovbjerg (Intern)

DTU centre for recirculation technology (38159)

Despite the obvious scientific relationship and correlation between recirculation technology, specifically biofiltration, and municipal waste-water treatment only limited scientific knowledge has been interchanged between these two areas.

DTU Environment has for many years been an internationally renowned actor within biofiltration processes and kinetics in waste water treatment. Combining this stronghold with the DTU Aqua expertise in recirculating systems is the basis for this project. Through project cooperation, student interchange and common research set-ups knowledge is exchanged and new insights developed.

In recirculation systems feed is the major input to the system, and the linkage between feed, water quality and system operation is important, yet missing knowledge, which will also be addressed by the group through a combined experimental and modeling approach.

Department of Environmental Engineering
National Institute of Aquatic Resources
Section for Aquaculture

Period: 01/01/2010 → 31/12/2015
Number of participants: 3
Research area: Aquaculture

Project participant:
Suhr, Karin Isabel (Intern)

Project Manager, academic:
Pedersen, Per Bovbjerg (Intern)
Pedersen, Lars-Flemming (Intern)

Helpdesk for aquaculture (HelpDesk) (38696)

In the project different environmental issues related to regulation of aquaculture have been addressed according to specific needs and questions from the Ministry of Food, Agriculture and Fisheries and the Ministry of Environment.

Specifically, a calculation model for predicting waste generated from fish farming has been developed. This Excel-based model is able to calculate the waste generated by the fish depending only on the fish performance (FCR) and the composition and digestibility of the feed used.

The model, valid for rainbow trout up to 800 g/pes in freshwater, was verified through various experiments using commercial feed types, and is now a central element in the regulation of the Danish freshwater trout farming industry. It is used throughout the industry and administration and has generated a common background and baseline for all stakeholders.
A group consisting of the Ministry for Food, Agriculture and Fisheries, the Ministry of Environment, the Danish municipalities' organization Local Government Denmark was formed and acted as reference/steering group.

The project was coordinated by DTU Aqua.

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
Period: 01/01/2010 → 30/11/2013
Number of participants: 3
Research area: Aquaculture
Project participant:
Dalsgaard, Anne Johanne Tang (Intern)
Pedersen, Per Bovbjerg (Intern)
Jokumsen, Alfred (Intern)

Project

Amino acid metabolism in gilthead seabream (Sparus aurata) - the fate of protein derived nitrogen

National Institute of Aquatic Resources
Period: 01/03/2009 → 06/02/2013
Number of participants: 8
Phd Student:
Ekmann, Kim Schøn (Intern)
Supervisor:
Campbell, Patrick James (Ekstern)
Dalsgaard, Anne Johanne Tang (Intern)
Holm, Jørgen (Ekstern)
Main Supervisor:
Skov, Peter Vilhelm (Intern)
Examiner:
Pedersen, Per Bovbjerg (Intern)
Damgaard Poulsen, Hanne (Ekstern)
Pereira de Oliva Teles, Aires Manuel (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Eksternt finansieret virksomhed
Project: PhD

Enzymes in fish feed: Optimization of protein digestibility in fish production (38396)
The demand for aquaculture products is increasing globally and is expected to keep increasing in proportion with the growth in the global human population. A limiting factor for the expansion of the aquaculture industry is the dependency of fish meal, which is the primary protein source in feed for carnivorous fish (trout, salmon, turbot, cod etc.). Increasing world market prices on quality fish meal is reflected in the price of fish feed, and has intensified the international competition for finding ways to optimise the use of alternative plant-based proteins in fish feed.

Enzymes are catalysts that increase the speed of the processes in which they are involved. A high degree of specificity makes enzymes an excellent tool for increasing specific reactions, e.g. the degradation of complex feed ingredients to digestible nutrients. The addition of enzymes to fish feed has the potential of improving the nutritional value of the feed, reducing production costs and loss of valuable nutrients to the environment. Enzymes are already widely used in feed for broilers and pigs, while only phytases have been approved for commercial fish production.

The objective of this project was to promote the use of industrial enzymes in fish feed as a means to improve the utilization by the fish of existing and/or alternative protein sources. The project consisted of four work packages: 1) Identification of relevant enzymes and feed ingredients; 2) Feed production; 3) Test of feed quality in a digestion model; 4) Data analyses, reporting and preparing publications. Low-grade soybean cake, sunflower cake and rapeseed cake were chosen as alternative plant-based protein sources in three diets. The effects of three exogenous enzymes in liquid form (Ronozyme®VP (β-glucanase, pectinase), Ronozyme®WX (xylanase) and an experimental protease) on nutrient digestibility was examined. The study showed that Ronozyme®VP and the experimental protease were able to significantly improve the nutrient digestibility primarily in the soybean cake diet at doses of 150-300 mg kg⁻¹. No clear
The effect of RONOZYME®WX on nutrient digestibility was observed with any of the ingredients tested. The overall conclusion of the project was that Ronozyme®VP and the experimental protease have potential to increase the nutritional and energetic value of proteinaceous plant-based feed ingredients in fish feed.

The project was coordinated by DTU Aqua.

National Institute of Aquatic Resources
Section for Aquaculture

BioMar A/S
Novozymes A/S
DSM Nutritional Products

Period: 01/01/2008 → 31/12/2010
Number of participants: 6
Research area: Aquaculture

RESTOCK (38568) (38400 pre-project)

The aim of the pre-project was to explore the potential for restocking the cod stock in the eastern Baltic. A theoretical study was conducted to explore the potential for restocking bringing together scientists from the aquaculture sector, fisheries managers, ecological scientists and scientists with a background in stock enhancement. The ecology, biology and fisheries study of the eastern Baltic was reviewed and provided the basis for the study. The results indicated a good potential for restocking with first-feeding cod larvae (Støttrup et al. 2008). This was the first example of a study to examine the potential for large-scale restocking prior to the release of fish. A 2-3-month delay in the spawning period compared to 20-30 years ago has altered feeding conditions and predation susceptibility in a way that may have exacerbated the decline in recruitment. Producing and releasing cod larvae during spring would mimic the spawning period recorded in previous times and would coincide with the spring peak in copepod production. An evaluation of 3 different release scenarios showed that a release of 474 million first-feeding larvae over 5 months (covering the historic and present day spawning period) would enhance the average population of 2 year old by 10% and be biologically and economically the most feasible scenario.

Three years of a six year follow up project (RESTOCK) to verify the theoretical findings was funded, but due to political changes, funding for the final three years was not possible and the project was unable to empirically ascertain the potential for restocking. During the three years, 3 cod broodstocks were established with different photoperiods and subsequent spawning periods, together with the development of a technique to determine fish gender non-invasively (McEvoy et al., 2009). Egg and larval incubation techniques were developed and several investigations on temperature, salinity and food impacts on first feeding cod larvae to define the “window of opportunity” for release (i.e. time when the larvae were ready to start feeding when they began to be too poor in condition to feed) (Støttrup et al., 2008; Overton et al. 2010; Meyer et al 2011a). A release strategy was developed and the first successful release of first-feeding fish larvae at 23 m depth was conducted, but needed further adjustments (Støttrup et al., 2008). An extensive disease monitoring program was established (Støttrup et al., 2008) and the presence of a protistan endoparasite generated a further study (Skovgård et al., 2010). Studies were also conducted to determine explore marking techniques for identification of released fish (Meyer et al., 2011b) and explore growth characteristics in cod larvae (Meyer et al., 2011a).

The project was coordinated by DTU Aqua.

National Institute of Aquatic Resources
Section for Ecosystem based Marine Management
National Veterinary Institute
Danish Fishermen's Association
University of Copenhagen
Monitoring and Documentation of the Performance of ModelTroutFarms (ModelTroutFarm)

De-coupling fish production and environmental impact is a sustainable way of increasing aquaculture. In order to achieve increased production and—simultaneously— reduced environmental impact a new farming concept was developed, tested and demonstrated.

Applying cost-efficient technologies from recirculation on large, traditional flow-through farms provided the basic concept for ModelTroutFarms. Through intensified production in concrete tanks, the former earthen ponds could be used as constructed wetlands for end-of-pipe treatment of the discharged water.

Due to recirculation, water consumption was reduced by a factor 25, so damming of natural water courses was no longer needed for supplying water to the farm. As a consequence, dammings could be removed leaving the water course to its natural flow.

A reduction of some 80 % in organic matter and phosphorous discharge was achieved, and 50 % of the nitrogen was removed.

Through the concept, technical and practical means of decoupling fish production and environmental impact was demonstrated in large scale commercial operations. Concomitantly, legislation was changed and now approximately 50 % of the Danish fresh water production is in ModelTroutFarms.

This project was coordinated by DTU Aqua.

National Institute of Aquatic Resources

Section for Aquaculture

Aarhus University

Eight trout farms
Period: 01/01/2003 → 31/12/2008
Number of participants: 4
Research area: Aquaculture
Project participant:
Rasmussen, Richard Skøtt (Intern)
Dalsgaard, Anne Johanne Tang (Intern)
Suhr, Karin Isabel (Intern)
Project Coordinator:
Pedersen, Per Bovbjerg (Intern)
Project

Monitoring and documentation of the performance of ModelTroutFarms (ModelTroutFarm) (38192)
De-coupling fish production and environmental impact is a sustainable way of increasing aquaculture. In order to achieve increased production and, simultaneously, reduced environmental impact a new farming concept was developed, tested and demonstrated.
Applying cost-efficient technologies from recirculation on large, traditional flow-through farms provided the basic concept for ModelTroutFarms. Through intensified production in concrete tanks, the former earthen ponds could be used as constructed wetlands for end-of-pipe treatment of the discharged water.

Due to recirculation, water consumption was reduced by a factor 25, so damming of natural water courses was no longer needed for supplying water to the farm. As a consequence, dammings could be removed leaving the water course to its natural flow.

A reduction of some 80 % in organic matter and phosphorous discharge was achieved, and 50 % of the nitrogen was removed.

Through the concept, technical and practical means of decoupling fish production and environmental impact was demonstrated in large scale commercial operations. Concomitantly, legislation was changed and now approximately 50 % of the Danish fresh water production is in ModelTroutFarms.

This project was coordinated by DTU Aqua.

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
Aarhus University

Eight trout farms
Period: 01/01/2003 → 31/07/2011
Number of participants: 4
Research area: Aquaculture
Project participant:
Rasmussen, Richard Skøtt (Intern)
Dalsgaard, Anne Johanne Tang (Intern)
Suhr, Karin Isabel (Intern)
Project Coordinator:
Pedersen, Per Bovbjerg (Intern)