European Food Safety Authority

The EFSA Journal (2008) 844, 1-21

SCIENTIFIC OPINION

Animal welfare aspects of husbandry systems for farmed European seabass and gilthead seabream[1]

Scientific Opinion of the Panel on Animal Health and Welfare

(Question N° EFSA-Q-2006-149)

Adopted on 22nd October 2008

[1] For citation purposes: Scientific Opinion of the Panel on Animal Health and Welfare on a request from the European Commission on animal welfare aspects of husbandry systems for farmed European seabass and Gilthead seabream. *The EFSA Journal* (2008) 844, 1-21

PANEL MEMBERS*

The Scientific Panel for Animal Health and Welfare (AHAW) of the European Food Safety Authority adopted the current Scientific Opinion on 22 October 2008. The Members of the AHAW Scientific Panel were:

Bo Algers, Harry J. Blokhuis, Anette Bøtner, Donald M. Broom, Patrizia Costa, Mariano Domingo, Mathias Greiner, Daniel Guemene, Jörg Hartung, Frank Koenen, Christine Müller-Graf, David B. Morton, Albert Osterhaus, Dirk U. Pfeiffer, Mohan Raj, Ronald Roberts, Moez Sanaa, Mo Salman, J. Michael Sharp, Philippe Vannier and Martin Wierup.

* A minority opinion was expressed from Prof. Donald Broom based on the view that the accepted Report and adopted Opinion are incomplete and that in order to answer the mandate from the European Commission, the introductory chapters on the welfare, biological functioning and farming of fish should be included (Annex II).

SUMMARY

Following a request from the European Commission, the AHAW Panel was asked to deliver a Scientific Opinion on the animal welfare aspects of husbandry systems for farmed seabass (*Dicentrarchus labrax*) and seabream (*Sparus aurata*). The Scientific Opinion was adopted on 22 October 2008.

From the available data, factors affecting farmed seabass and seabream welfare were identified which led to conclusions in the Scientific Opinion. These factors are grouped as: abiotic and biotic factors and behavioural interactions, food and feeding, husbandry and management, genetic selection and the impact of disease and disease control measures. A risk assessment was carried out to obtain a ranking of risk and compare the production systems.

Sea basss and sea bream are eurythermal and euryhaline species, tolerating wide range of temperature and salinity variations. Rapid and elevated changes of temperature close to the thermal limits are more likely to lead to poor welfare. Seabass and seabream are tolerant species capable of coping with large ranges of dissolved O_2 concentrations through physiological adjustments. In cages, however dissolved O_2 is a limiting factor at high temperatures. O_2 saturation in outlet water should be monitored daily and should be maintained above 40% saturation. Further studies are recommended on the combined effects of high O_2 and CO_2 levels on different stages. Seabass and seabream can be considered tolerant to pH variations. There is an increased risk of poor welfare at pH values below 6.0 and above 8.5. The daily monitoring of the water pH in recirculated (RC) and ongrowing flow-through (FT) systems are recommended. More studies are needed to evaluate the combined effects of low pH and elevated CO_2 concentrations. Super saturation is a rare but serious cause of loss in farmed fish, with serious welfare implications when it occurs. CO_2 concentration depends on pH, temperature and salinity of the water as well as the respiration of the fish and other organisms. Its management is complex in RC systems and can become a welfare issue. Studies on the CO_2 tolerance and possible welfare implications are recommended. High stocking densities and insufficient water flow may result in build up of ammonia in the water. Sub-lethal concentrations of ammonia can damage the gills and also impair immune function leading to increased susceptibility to infectious disease but further research is necessary to determine potential welfare effects of long term exposure to low levels of unionized ammonia nitrogen. Photoperiod is an important factor conditioning larvae growth and development and also the induction of spawning. The welfare consequences of artificial photoperiod, if any, are not fully understood. Ammonia and other metabolites may cause poor welfare where inadequate water flows occur. There is, however, very limited information about flow rate requirements in tank systems

Stocking density can affect welfare because of its consequences on fish social interactions and water quality. Stocking density per se (biomass/volume) cannot be used as a good indicator to predict welfare. Intra-specific aggression (including cannibalism) in post larvae can be problematic and avoidance by maintaining grading and adequate stocking densities and water flow is necessary. At the post larval stage, husbandry parameters, such as adequate stocking density, water flow and feed access should be maintained to avoid intra-specific aggression. While predation damage and the presence and predation activities are undoubtedly a significant welfare issue for seabass and seabream in certain systems, there is no systematic data available on the scale of the problem. Clear guidance based on scientific evidence on the issue of predator control should be developed and provided to the fish farming industry.

Larval first feeding is a very sensitive stage where both high quality and abundant live feeds has to be provided to the fish in order to obviate a welfare compromise. Post larvae and

ongrowing stages are less sensitive to feeding strategy providing that even access to feed is allowed to all fish in order to avoid aggression. At the larval stage, inadequate size and quantities of live feed in the diet can cause empty gut, metabolic stress, impaired growth and at worse fasting leading to death. Fish are exposed to various husbandry stressors during all stages of the life cycle in intensive culture conditions that can lead to injury, stress, increased disease susceptibility and impaired performance. Proper equipment, handling and anaesthetic protocols are important to minimize stress and physical damage associated with handling procedures. Assessment of seabream and seabass sex and sexual maturation by urogenital catheterization biopsy is an invasive stressful procedure that may threaten fish health and reproductive performance. Viral Nervous Necrosis is an important disease for seabass production with major implications in fish behaviour and welfare as no commercial vaccines are available and no treatment is possible. Monogenan parasites, winter syndrome, vibriosis and pasteurellosis are common problems in most farms and can become a significant welfare problem if not effectively controlled. Availability of veterinary medical products for seabream and seabass is very limited. Vaccines have made a significant contribution to controlling serious infectious diseases; however further research is recommended.

The risk assessment outcomes showed that in the majority of farms monitoring of health and production management is carried out to a high standard, with the possible exception of handling procedures. Hazards when they occur are generally quickly detected and corrected. Poorly formulated feed and poor storage, which may cause low level chronic effect and may go undetected was highly scored hazard for a number of life stages and across production systems (except extensive). The failure of fish to adapt to feed distribution modes and feed storage conditions during the summer months are important hazards in some stages and are open to improved management. The lack of availability of authorised anaesthetics for use in broodstock was an important hazard. Disturbance to the fish due to routine management is inevitable to a degree but management practices should be implemented that minimise the effect on fish.. There were no significant differences between larve, juveniles and ongrowers in flowthrough tanks compared with recirculation systems. The main hazards were associated with management (e.g.handling, disturbance, poor tank hygiene), feed and disease. In extensive systems predation and water temperature were important hazards for ongrowers and juveniles. The impact of infectious and non-infectious diseases in flowthrough, recirculated and also in extensive systems is an important hazard.

Key words: seabass, seabream, welfare, risk assessment, fish-farming, abiotic factors, biotic factors, feeding, husbandry, disease.

TABLE OF CONTENTS

BACKGROUND AS PROVIDED BY EUROPEAN COMMISSION

Council Directive 98/58/EC concerning the protection of animals kept for farming purposes lays down minimum standards for the protection of animals bred or kept for farming purposes, including fish.

In recent years growing scientific evidence has accumulated on the sentience of fish and the Council of Europe has in 2005 issued a recommendation on the welfare of farmed fish[2]. Upon requests from the Commission, EFSA has already issued scientific opinions which consider the transport[3] and stunning-killing[4] of farmed fish.

TERMS OF REFERENCE AS PROVIDED BY THE EUROPEAN COMMISSION

In view of this and in order to receive an overview of the latest scientific developments in this area the Commission requests EFSA to issue a scientific opinion on the animal welfare aspects of husbandry systems for farmed fish. Where relevant, animal health and food safety aspects[5] should also be taken into account. This scientific opinion should consider the main fish species farmed in the EU, including Atlantic salmon, Gilthead seabream, Seabass, Rainbow trout, carp and European eel and aspects of husbandry systems such as water quality, stocking density, feeding, environmental structure and social behaviour.

Due to the great diversity of species it was proposed that separate scientific opinions on species or sets of similar species would be more adequate and effective. It was agreed to subdivide the initial mandate into 5 different questions:
Question 1. In relation to Atlantic salmon
Question 2. In relation to trout species
Question 3. In relation to carp species.
Question 4. In relation to seabass and gilthead seabream
Question 5. In relation to European eel

This Scientific Opinion refers only to Question 4 as referenced above

ACKNOWLEDGEMENTS

The European Food Safety Authority wishes to thank the members of the Working Group for the preparation of this opinion: Ronald Roberts (WG Chairman), Ed Peeler (Risk Assessor) Marie-Laure Bégout, Gilles Lemarié, Giovanna Marino, Michalis Pavlidis and Francesc Padrós.

2 Recommendation concerning farmed fish adopted by the Standing Committee of the European Convention for the protection of animals kept for farming purposes on 5 December 2005

3 Opinion adopted by the AHAW Panel related to the welfare of animals during transport -30 March 2004

4 Opinion of the AHAW Panel related to welfare aspects of the main systems of stunning and killing the main commercial species of animals- 15 June 2004

5 Food Safety aspects are addressed by a Scientific Opinion of the BIOHAZ Panel (Food Safety aspects of Animal welfare aspects of husbandry systems for farmed fish, Question N° EFSA-Q-2008-297).

CONCLUSIONS AND RECOMMENDATIONS

1. OUTCOMES FROM THE DATA PRESENTED IN THE SCIENTIFIC REPORT

1.1. Abiotic Factors

1.1.1. Temperature

Conclusions

- Seabass and seabream are eurythermal fish. Minimum and maximum survival water temperatures are 2-32 °C and 5-34 °C for seabass and seabream respectively. Early life-stages, eggs, larvae and juveniles have more limited temperature tolerance during ontogenesis.
- Temperature tolerance is highly dependent on acclimation. Rapid and substantial changes of temperature close to the thermal limits are likely to lead to poor welfare.
- Seabream are sensitive to cold temperatures. Acute temperature decreases (from 15 °C to 9 °C) have been shown to be significant thermal stressors. When cold-induced fasting is prolonged, it significantly affects metabolism and physiology of seabream, and it has been associated with the onset of winter disease.

Recommendations

- For seabass, the temperature ranges 10-20 °C for eggs, larvae and 8-28 °C for larger fish should be recommended in terms of acceptable welfare.
- For seabream, the temperature ranges 12-22 °C for eggs, larvae and 8-30 °C for larger fish should be recommended in terms of acceptable welfare.
- During incubation and early development stabilized water temperature should be maintained. During the ongrowing phase, any rapid changes of temperature should only occur within the recommended thermal ranges. Temperature changes exceeding 5 °C /day should be avoided

1.1.2. Oxygen

Conclusions

- The available dissolved oxygen (mg l^{-1}) in water depends on temperature, salinity, partial pressure of ambient oxygen, stocking density and water renewal.
- Seabass and seabream are very tolerant species capable of coping with large ranges of dissolved oxygen concentrations through physiological adjustments. The relative oxygen consumption (mg O_2 kg^{-1} fish h^{-1}) in both species increases with temperature, activity, feed consumption and stress level, while it decreases with increasing body size.
- The concentration of oxygen available to fish varies across different production systems. In cages, dissolved oxygen is a limiting factor at high summer temperatures. Such problems do not normally arise in flow-through or recirculated systems except in

the event of mechanical breakdown. At 40% oxygen saturation feed intake and growth are impaired in seabass and seabream.

- The combination of high oxygen (230-250% O_2 saturation) and high carbon dioxide (50-60 mg $CO_2\,l^{-1}$) increases mortality in seabass after bacterial challenge.

Recommendations

- The oxygen saturation in outlet water should be monitored daily and, as a guideline, should be maintained above 40% saturation. Siting, cage design, cage orientation, bio-fouling control and stocking density should be optimised to avoid chronic hypoxic conditions in cages

Recommendations for future research

- Further studies are needed on the combined effects of high O_2 and CO_2 levels on different life stages.

1.1.3. pH

Conclusions

- Seabass and seabream are able to maintain balanced acid/base concentrations and constant internal pH even when pH in ambient waters varies widely. Both species can therefore be considered as tolerant to pH variations.
- In cages, seawater pH variations are too small to become a welfare issue.
- There is an increased risk of poor welfare at pH values below 6.5 and above 8.5 for both seabass and seabream and mortality can occur when fish are exposed abruptly to a pH below 4.5 and above 9.4, but this is unlikely to happen in normal practice.
- In flow-through land based farms, pH level depends mainly on CO_2 concentrations due to fish respiration. In case of low water renewal rate combined to high levels of oxygen supplementation in inlet waters, the CO_2 concentrations per se in ambiant water may have detrimental effects on fish before the altering pH levels.
- In recirculated systems, pH depends on CO2 concentrations and also on the level of H+ produced by the biological filter. When CO2 is removed by the use of packed columns, the pH may nevertheless reach low values (<6) and there is limited information on the welfare implications of such circumstances.

Recommendations

- Water pH should be monitored closely in recirculatedg and ongrowing flow-through system using low water renewal and supplementary dissolved oxygen.
- Water pH values in the range 6.5 to 8.5 ensure good welfare in seabass and seabream. pH values below 5 and above 9 impair growth and welfare.

Recommendations for future research

- The effect of pH on early life stages is not well-known and further investigations are required as this is a particularly vulnerable element of the production cycle.
- More studies are necessary to evaluate the combined effects of low pH and elevated CO_2 concentrations

1.1.4. Carbon Dioxide

Conclusions

- Carbon dioxide (CO_2) concentration depends on pH, temperature and salinity of the water as well as the respiration of the fish and other organisms in the water its management is complex in recirculating systems and can become a welfare issue.
- CO_2 concentration is not normally a welfare issue in cage systems, but can become one in some circumstances in flow through systems.
- Lethal concentration in juvenile seabass (LC 50 at 96 h, at 15 °C) is close to 112.1 m CO_2 l^{-1} (50.4 mm Hg). Seabass can, however, compensate for blood acidosis at water concentrations of CO_2 around 55 mg l^{-1} and no mortality or reduced growth has been observed under chronic hypercapnic conditions (up to 75 mg l^{-1} for 45 days). There is no available information for seabream.

Recommendations for future research

- Further research is recommended in relation to the CO_2 tolerance of seabream and possible welfare implications.
- Since nephrocalcinosis would appear to be a factor of welfare significance even at low levels of CO_2, practical studies are justified under commercial conditions on seabass and seabream farms to determine threshold CO_2 levels.

1.1.5. Supersaturation

Conclusions

- Super saturation is a rare but serious cause of loss in farmed fish, with serious welfare implications when it occurs.

1.1.6. Ammonia

Conclusions

- High stocking densities and insufficient water flow may result in build up of ammonia in the water. Ammonia is present in ionised and un-ionised forms. The level of the more toxic form, the un-ionised ammonia is dependent on total ammonia level, pH, temperature and salinity.
- Sub-lethal concentrations of ammonia can damage the gills and also impair immune function leading to increased susceptibility to infectious disease.
- The 0.26-mg l^{-1} UIA-N concentration can be considered as a safe long-term limit in seawater for seabass juveniles.
- Ammonia in seawater is not a welfare issue in on-growing cage systems because it is diluted generally at non-limiting levels by the ambiant water streams.

Recommendations for future research

- Further research is necessary to determine potential welfare effects of long term exposure to low levels of unionized ammonia nitrogen.

1.1.7. Salinity

Conclusions

- Seabass and seabream are euryhaline fish capable of tolerating both high saline waters and freshwater environments. Gradual changes in salinity are not a welfare issue in seabass and seabream farming.
- Despite their tolerance of wide salinity ranges, both species are sensitive to rapid changes in salinity.

Recommendations

- Seabass and seabream should not be subjected to rapid and significant changes of salinity.

1.1.8. Light/ Photoperiod

Conclusions

- Photoperiod is an important factor conditioning larvae growth and development and also the induction of spawning. Photoperiod treatments can be employed to advance or delay the spawning time.
- The welfare consequences of artificial photoperiod, if any, are unknown.

Recommendations

- Photoperiod manipulation to modify the male sex ratio in seabass is becoming a useful husbandry tool. The welfare implications of this are not known and this area should be investigated.

1.1.9. Water renewal / Water exchange rate / Specific water flow

Conclusion

- Ammonia and other metabolites may cause poor welfare where inadequate water flows occur in all seabass and seabream culture systems. There is, however, very limited information about flow rate requirements in tank systems
- In cage culture there is a particular risk of poor welfare in the case of inappropriate site selection and unfavourable managerial practices. The measurement of the water renewal rate in cages is difficult and the measurement of water oxygen concentration is the most accurate and current-induced measure of water quality

Recommendations

- In cage culture proper site selection, antifouling practices and appropriate changing of nets are recommended to ensure sufficient water exchange.

Recommendations for future research

- More research is needed to explore risks of poor welfare at different water renewal rates in seabass and seabream in the different life stages.
- There is a significant requirement for further studies on definition of inter-relationships between water flow, water quality and stocking density in culture systems for both seabass and seabream.

1.2. Biotic factors / Behavioural interactions

1.2.1. Stocking density

Conclusions

- Stocking density per se (biomass/volume) cannot be used as a good indicator to predict welfare. Stocking density can affect welfare because of its consequences on fish social interactions and water quality. In addition, crowding can lead to poor welfare.

Recommendations

- In considering the effects of stocking density on farmed seabass or seabream it is recommended that monitoring of the condition of the fish and the water quality is the appropriate route for preventing poor welfare.
- When short-term high stocking densities are necessary for husbandry manipulations, close attention to water quality, fish health and behaviour should be maintained.

1.2.2. Intraspecific interactions: Aggression and competition

Conclusions

- Intra-specific aggression (including cannibalism) in post larvae can be problematic and its prevention by maintaining a uniform size distribution, adequate stock density and water flow is necessary.
- Feeding regime determines competition for feed amongst gilthead seabream which can influence feeding behaviour and feeding efficiency.

Recommendations

- In pre-ongrowing seabream, the development of competition and aggression can be prevented, principally by simultaneously adjusting stocking density and ensuring proper feed access.
- In seabass post-larvae, husbandry parameters, such as adequate stocking density, water flow and feed access should be maintained to avoid intraspecific aggression.

1.2.3. Predation

Conclusions

- While predation damage and the presence and predation activities are undoubtedly a significant welfare issue for seabass and seabream in certain systems, there is no systematic data available on the scale of the problem.
- The efficacy of the methods developed to prevent or minimise predation are very variable. There is also a lack of any rigorous scientific investigation or clear practical advice for farmers on the methods to be used to control the predation.
- Birds may predate upon seabass and seabream in ponds, lagoons and sea cages but predation by marine mammals is not documented.

Recommendations

- In pond and lagoons systems, predation should always be controlled (by netting or other methods), whenever possible. Control of cormorants is particularly difficult and the welfare of the fish as well as the cormorants should be considered in any control strategy.
- Clear guidance based on scientific evidence on the issue of predator control should be developed and provided to the fish farming industry.
- Data should be collected on the extent of predation in seabass and seabream culture, the control methods used and their efficacy, including their impact on predators.

1.3. Food and Feeding

Conclusions

- Larval first feeding is a very sensitive stage where both high quality and abundant live feeds has to be provided to the fish in order to preserve good welfare.
- Post-larvae and ongrowing stages are less sensitive to feeding strategy providing that even access to feed is allowed to all fish in order to avoid aggression.
- Inadequate feed formulation and quality problems can induce larval deformities and impaired growth.

Recommendations

- Feed quantity, distribution and quality should be sufficient to avoid poor welfare associated with stress and intra specific interactions including competition and cannibalism at larvae, juvenile and pre-ongrowing stages.

1.3.1. Food deprivation and starvation

Conclusions

- At the larval stage, food deprivation can have severe effects on fish. Inadequate size and quantities of live feed in the diet can cause empty gut, metabolic stress, impaired growth and at worse fasting leading to death.
- Ongrowing and brood fish are more tolerant to feed deprivation but nevertheless if prolonged it can lead to inappropriate social interactions affecting welfare.

1.4. Husbandry and Management

Conclusions

- Fish are exposed to various husbandry stressors during all stages of the life cycle in intensive culture conditions that can lead to injury, stress, increased disease susceptibility and impaired performance.
- Proper equipment, handling and anaesthetic protocols are important to minimize stress and physical damage associated with handling procedures.
- Eggs and larvae are fragile in handling and abrupt temperature changes that can lead to mortalities and developmental deformities.
- Out-of-season spontaneous spawning is feasible in both seabass and seabream by the use of photoperiod and temperature manipulation. Hormonal induced spawning is not in practice for seabream and has a limited use in seabass broodfish.
- Broodstock should always be handled by well-trained personnel and under sedation to minimize physical damage and stress. Currently there is only one anaesthetic approved for use in fish that is generally considered less suitable than other unlicensed alternatives
- Grading is an important part of husbandry at the juvenile and pre-ongrowing stages as it prevents the development of aggression and cannibalism, results in better performance and facilitates daily husbandry activities. However, grading may cause physical injury and stress.
- Sort-term handling, crowding and confinement and daily cleaning activities may result in the activation of the classical physiological stress response in fish, however, physiological and behavioural changes are normally reversible and fish recover within 24 h following exposure to the stressor.
- Intense activities like prolonged crowding and transportation between units or between different fish farms may cause physical injury and major physiological and behavioural changes where the animal is unlikely to cope or adapt to the stress being imposed.
- Assessment of seabream and seabass sex and sexual maturation by urogenital catheterization biopsy is an invasive stressfull procedure that may threaten fish health and reproductive performance.

Recommendations

- Fish should be handled solely by skilled personnel and only for essential husbandry and veterinary purposes.Handling should be performed with special care to avoid physical injury and damages and to minimize stress.
- Abrupt changes in water temperatures should be avoided during transport of eggs, larvae and fry between the different units of the hatchery or between different hatcheries.
- There is a need for authorised anaesthetics and prophylactic agents for use in seabass and seabream farming.

Recommendations for future research

- Further research on the use of ultrasonogaphy and other non invasive methods in sex and sexual maturity determination in seabream and sebass is necessary.

1.5. Genetic selection impact on welfare

Recommendations for future research

- Research is necessary on monitoring if genetic selection programs affect traits that will negatively impact welfare.

1.6. Impact of disease on welfare

1.6.1. Viral Nervous Necrosis (VNN) / Viral encephalopathy and retinopathy (VER) / Nodavirus infection

Conclusions

- VNN is an important disease in seabass production. VNN affects the central nervous system and has major implications in fish behaviour and welfare
- Broodstock testing for Nodavirus carriers, disinfection of the incoming water and strict hygiene of the facility and husbandry practices can be effective measures to guarantee the quality of fry and juveniles supplied to ongrowing units.No commercial vaccines are available and there is no treatment.

Recommendations

- Official and non-official survey and control programmes should be recommended
- The efficacy of the specific biosecurity measures for this condition should be further improved.
- Development of effective vaccines should be encouraged
- As the management of the mortality is a critical issue in the control of the disease, the procedures for the removal of dead or moribund fish should be improved.

1.6.2. Monogenean infections

Conclusions

- Monogenan parasites are common and persistent problems in most seabream and seabass farms and can become a significant problem with welfare implications if they are not effectively controlled.
- Preventive treatments using formalin or hydrogen peroxide are useful but cannot always be carried out. Therefore, routine net and tank cleaning operations, in addition to other preventive measures, are the most reliable means to control the level of the parasites and keep the disease at a low level.

Recommendations

- In order to maintain the level of the parasites and the disease at a low level prophylactic controls at farm level should be improved.
- A wider range of antiparasitic drugs against monogenean infections should be developed and made available.

1.6.3. Winter syndrome

Conclusions

- Winter syndrome is a disease that is associated with strong metabolic and immunological disturbances in seabream in some farming practices at low temperatures for long periods.
- Correct management before the cold season (avoid feeding when temperatures are low and reduce stressful management) minimises the risk of the disease.

Recommendations

- The low temperature at which there is increased risk of winter syndrome disease in each area where sea bass are farmed should be determined in relation to the fish strain and farming conditions
- Correct nutritional and husbandry measures before the cold period to prepare the fish to achieve an adequate metabolic status should be encouraged.

1.6.4. Vibriosis

Conclusions

- Vibriosis can be a secondary pathology often associated with unappropriate handling and management procedures in intensive systems.
- Vibriosis are a common group of diseases that affect seabass and seabream but the disease is usually controlled by the use of approved antibiotics given in the feed,
- Vibriosis prevention can be effectively achieved by the use of a correct vaccination protocol using commercial vaccines but it can still be a serious problem in hatcheries as protection can only be achieved after vaccination at 2-3 grams.

Recommendations

- Careful and efficient sanitary controls on farms including prophylactic measures such as a vaccination with rapid diagnostic and treatment programmes should be recommended as the main ways to control this disease.

1.6.5. Pasteurellosis

Conclusions

- Pasteurellosis is a significant disease affecting seabass and seabream. When there is an outbreak, the disease is usually controlled by the use of approved antibiotics given with the feed.

- Pasteurellosis prevention can be effectively achieved by the use of a correct vaccination protocol using commercial vaccines, although the efficacy of these vaccines needs to be improved.

Recommendations

- Careful and efficient sanitary controls on farms including prophylactic measures such as a vaccination with rapid diagnostic and treatment programmes should be recommended as the main ways to control this disease.
- Research on vaccines with increased efficacy and reduced side effects should be envisaged.

1.6.6. Lymphocystis

Conclusions

- Lymphocystis is a benign disease that spontaneously disappears if rearing conditions are correct

Recommendations

- Good husbandry conditions during the infection should be implemented for a quick and total recovery and stressful and rough manipulation should be avoided.

1.7. Disease Control Measures

Conclusions

- Availability of veterinary medical products approved for seabream and seabass is very limited and this constitutes an important risk for poor welfare caused by disease.

Recomendations

- Measures should be taken to facilitate rapid and beneficial release of efficacious veterinary medicinal products.

1.7.1. Vaccination

Conclusions

- Vaccines have made a significant contribution to controlling serious infectious diseases in seabream and seabass.

Recomendations for future research

- Research for development of vaccines with a long lasting immunity should be carried out.

1.7.2. Biosecurity

Conclusions

- Individual farm biosecurity strategies with mandatory protocols are a major advantage in controlling the spread serious infectious disease.

Recomendations

- Seabass and seabream fish farms should be operated under agreed biosecurity plans subject to audit by a veterinarian.

2. RISK ASSESSMENT

2.1. Risk Assessment Discussion

2.1.1. Eggs

In this life stage, in both flow-through and recirculated production systems all hazards occurred with low probability (scoring 1 or 2). Hazards considered at the egg stage were important because of embryonic abnormalities, which may persist through later life stages. It should be taken into consideration that welfare *per se* is not relevant at this life stage.

- Flow-through

In the flow-through system the highest ranked risks were sudden change in temperature and inappropriate transport between units, which would cause significant mortality, followed by low water renewal and a sudden change in dissolved oxygen. The high score for inappropriate transport was mainly attributable to the fact that a high proportion of the population was affected. The sudden change in temperature has the highest severity score.

- Recirculation

Three hazards stood out in the recirculation system: low water renewal, inappropriate transport and sudden change in temperature.

A range of deformities will arise from the listed hazards, some of which may result in mortality after days, others will resolve in time.

2.1.2. Larvae

- Flow-through and Recirculation systems

The highest ranked hazards (in ranked order) for larvae in flow-through and recirculation systems were:

1. Inadequate stocking density
2. Inappropriate water velocity
3. Inadequate feed formulation and storage conditions
4. VNN / VER / Nodavirus infection

It should be pointed out that there is a big scoring difference between the four highest scored hazard and the rest of the hazards in the list (~0.010 vs ~0.003, see Tables).

- The inadequate stocking density hazards scored highly because they persist for 40 days and occurred relatively frequently
- Inappropriate water velocity scored highly mainly because it had a high severity score (3) and the effect lasted 21 days.
- Iinadequate feed formulation/storage conditions had a severity scores of 3.

- Disease (VER/VEN/nodavirus) was the fourth highest ranked hazard. These diseases only occur infrequently (probability score = 1) but affect a high proportion of the population with high severity. The outcome is frequently death, thus the mortality score is also high. The period of clinical disease, prior to mortality, is approximately 5 days.

2.1.3. Juveniles

This stage lasts about 50 to 90 days. Fish are growing rapidly and removal of fish generally occurs twice to maintain a consistent stocking density (kg/m^3). Three systems were considered: flow-through, recirculation, and extensive.

- Flow-through and Recirculation systems

- In both systems poor tank hygiene receives a much greater score than any other hazard, attributable to a high severity score, a high proportion of the population affected and long duration (70 days).
- VNN/VER/nodavirus was an important hazard during the larval stage and remains important (second most highly ranked hazard) for juveniles in flow-through tanks and recirculation systems but not in extensive systems.
- Monogenean infections received high scores in tanks and recirculation systems. There is a lower probability of the disease hazards occurring in the recirculation systems, compared with the flow-through tanks. However, in recirculation systems the impact of monogeneans may be more severe. Poor biosecurity will lead to infection that will last 30 days.
- Abdominal adhesions due to vaccination (vaccine side effects) also ranked highly. Other adverse effects of vaccination by bath challenge were considered to be handling and crowding, which were considered separately. Handling did not feature as a highly ranked hazard. However data presented in the Scientific Report clearly indicates that handling is a welfare hazard, especially because the lack of anaesthetic and repeated manipulations of juveniles during this period for different purposes.

- Extensive

In extensive systems, considered hazards were different to the other 2 systems. Overall fewer hazards were identified, (n=4) and the value of the highest ranked hazard (predation) was approximately half the value of the highest ranked hazard in the more intensive sytems.

- Predation was by a very wide margin the most important hazard. Its high score was due to the severity (mainly physical injury) and duration of the effect of the hazard.
- Extreme temperature was another important hazard because whilst the conditions occurred relatively infrequently, if affected a high proportion of the population and affected them for on average 14 days.

These hazards reflect the nature of the systems. There exists an inherently reduced capacity to influence the environmental parameters in extensive compared with other systems.

2.1.4. Ongrowers

Handling issues and inadequate feed formulation / storage were the most important hazards in sea cages, recirculated and flow-through tanks.

Inadequate feed formulation and storage scored highly because it affects a high proportion of the population, has a relatively high probability (3) and severity score (3) but above all because of a high estimated duration (150 days). Handling (not according to best practice) was judged to occur in nearly all farms, affecting the entire population for approximately 30 days with moderate severity (2).

In recirculated and flow-through tanks disturbances mechanical failure and. Mechanical failure may cause stress because of the decline in water quality parameters. It is assumed that the fault is corrected relatively promptly and the fish recover relatively quickly (if they have survived). Similarly, adverse water quality parameters in recirculation systems are relatively short-lived since the farmer rectifies the problem or the fish die rapidly. The effect of untrained personnel is always expressed through the other hazards of the list, therefore untrained personnel as a has not been scored. In sea cages, poor adaptation to feed distribution was assessed as a high risks

Clear difference exists between the extensive and the other systems. In extensive systems few hazards were identified for ongrowers compared with other systems. Almost no handling occurs in extensive systems at this stage. Feed formulation is not an important issue in extensive systems as natural feed represents an important complement. The main hazards for ongrowers in extensive systems are disease, and predation. In sea cages, protective nets normally prevent bird predation. Failure in the system leading to predation will be, in general, quickly corrected and so predation does not score highly. In more extensive systems protective nets are not practicable.

In extensive and semi-intensive systems, algal blooms and lack of artificial oxygenation system may cause hypoxia. It did not however achieve a high score because it had a low probability score (1) and duration was estimated to be only 7 days.

The difference between the extensive and other systems reflect the nature of the inherently lower level of disease management and predator control that is attainable under extensive systems. However, these systems are better in terms of reduced disturbance and feed formulation and storage scoring a much lower.

2.1.5. Broodstock

The welfare of broodstock is particularly important since fish might be fertile for a number of years. Two hazards stood out: high stocking density and not using anaesthetics. The manipulation of broodstock without the use of anaesthetics occurs because anaesthetics are not licensed for seabass or bream in the EU. Manipulation without anaesthesia was considered to be a hazard with low severity (1) but affects all broodstock for approximately 63 days during this life stage. Similarly high stocking density received a low severity score (1) but since it lasted for 300 days the final score was high.

The following hazards attained considerably lower scores: inadequate feed formulation and storage conditions, inadequate feed size and improper sexing. Inaccurate sexing of broodstock may lead to an absence of males, and female seabream may retain eggs leading to reproductive dysfunctions and/or mortality.

2.2. Conclusions

- In the majority of farms monitoring of health and production management is carried out to a high standard, with the possible exception of handling procedures. Hazards when they occur are generally quickly detected and corrected.
- Inadequate feed formulation was a highly scored hazard for a number of life stages and across production systems (except extensive). It scores highly because it occurs relatively frequently, and lasts for much of the life stage. This hazard is partly outside of the control of the fish farmers and is an issue that needs to be pursued with the feed manufacturers. The main problem lies with the quality of the protein.
- The failure of fish to adapt to feed distribution modes and risks associated with poor feed storage conditions during the summer months (which results in a decline in feed quality), are important risky hazards in some stages and are open to improved management.
- The lack of availability of authorised anaesthetics for use in broodstock was an important hazard in this life stage.
- Poor handling was highlighted in a number of life stages and could be improved through training and better management.
- The highest ranked hazard for larvae was inappropriate water velocity.
- Disturbance to the fish due to routine management is inevitable to a degree but management practices should be implemented that minimise the effect on fish.
- There were no significant differences between larve, juveniles and ongrowers in flowthrough tanks compared with recirculation systems. The main hazards were associated with management (e.g.handling, disturbance, and poor tank hygiene), feed and disease.
- In extensive systems predation and water temperature were important hazards for ongrowers and juveniles. The impact of infectious and non-infectious diseases in flow through recirculated and also in extensive systems can also be considered as an important hazard.