Benchmark Genetics

ATLANTIC SALMON HATCHERY MANUAL

EGG TO FIRST FEEDING

Atlantic salmon eggs and alevins go through several stages and life-cycle events before becoming a free-swimming fry. Each stage and event has its own characteristics and environmental requirements, these are covered in different sections of this manual.

Disclaimer

Every attempt has been made to ensure the accuracy and relevance of the information presented in this document. Benchmark Genetics Limited however, accepts no liability for the consequences of using this information for the management of Atlantic salmon or for any other purpose.

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WHAT WE DO

Our business is based on more than 40 years of experience of delivering high-quality genetic material into the global Atlantic salmon market. Benchmark Genetics is a global breeding company operating advanced breeding programmes for Atlantic salmon, tilapia and shrimp.

The company runs three nucleus programmes for Atlantic salmon in Norway, Iceland and Chile supplying the SalmoBreed and StofnFiskur strains to producers around the world. Atlantic salmon are selected using a balanced breeding approach for improved growth, disease resistance and efficiency.

Achieving the genetic potential depends on farming practices and the conditions in which the animals are held. Sub-optimal conditions will reduce performance. The aim of this document is to describe good practice for Atlantic salmon eggs, alevins and fry, allowing producers to develop best practice management procedures for their operation.

Information presented in this document combines data derived from internal research trials, published scientific knowledge with the expertise, practical skills and experience of the Benchmark Genetics technical service teams, and sister companies in the Benchmark Group. The information contained is consistent with standard industry welfare guidelines produced by industry bodies — see *Further Reading*.

Ordering eggs

To place an order for eggs please contact the local Benchmark Genetics sales manager. To provide the best customer service please make contact as soon as possible. Changes to any order are best made as early as possible to allow the incubation centre supplying the eggs to make adjustments.

The Benchmark sales team will follow up on orders both before and after delivery. Our experienced technical and sale teams are always available to assist you with any logistical, quality or production related issues that may arise.

USEFUL CONTACTS:

SalmoBreed

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SECTION 1

ENVIRONMENTAL PARAMETERS

The requirements of the eggs and juveniles vary between stages. Water temperature, flow rate, water quality and lighting are important parameters for each stage, whilst feeding practice and feed quality becomes important at first feeding and beyond.

Temperature

Eggs are usually transported at temperature range between 2-5°C.

The rate of embryo development and growth of alevins and fry depend upon water temperature, with slower development at cold temperatures and faster development at higher temperatures. Water temperature can be used to control date of hatching as well as development.

Incubation temperatures of above 8°C can result in an increased level of skeletal deformity (6°C in triploids). Alevins can be held initially in temperatures up to 8°C, although increasing temperatures can increase the potential of skeletal deformities.

Time of development is measured in degree days. Degree day is defined as water temperature (°C) multiplied by number of days

Total degree days = water temperature x number of days

Key events such as hatching and first feeding happen after a defined number of degree days as described in subsequent sections. At temperatures of < 5°C, however, development is faster than predicted by the degree days, and consequently key events may occur earlier than predicted. For more information see *Terminology* at the end of this manual or use the online hatching calculator.

Water flow

Water flow rates should be sufficient to maintain oxygen level above 80% saturation in the outlet and remove metabolites. Water rate should be regularly checked at several points in the hatchery to ensure that there are no dead spots.

Oxygen

Oxygen should be measured daily at critical points in the system considering the locations where greatest risk of deviation would result in stress to the eggs or fish. Each stage of the hatchery should be monitored for several days at full water flow before stocking. A level of not less than 80% oxygen saturation in outlet water should be considered the target.

Carbon Dioxide

Carbon dioxide levels are an indication of the rate of metabolism in the system. Excess carbon dioxide can cause pH reduction. Levels should be maintained at <6 mg/l for eggs and alevins <15mg/l for fry measured at the outlet.

Total Gas

Total gas should be measured at least weekly, and whenever changes are made that may affect the total gas content e.g. temperature or water flow adjustment.

Nitrogen is the gas that most often leads to supersaturation (due to leaks in pumps or couplings, pipes that are in a negative pressure or considerable heating of water without adequate ventilation). Reduced water depth during first feeding can often lead to problems with supersaturation since fish are unable to use depth to control the water pressure they are exposed to. If total gas increases above 100% there is a danger of bubbles forming in tissues with detrimental effects on affected eggs or fish.

Water pH

pH is an important water parameter that must be carefully monitored throughout the whole season. For example, eggs hatching in late-Summer may experience different water parameters to those eggs hatching in Winter.

Although salmon can withstand a higher range, the optimal pH for Atlantic salmon eggs and alevins is 6.2-6.8. pH can be controlled by flow rates and addition of hydrated lime or bicarbonate. At pH below 6.0, there is a risk that metal ions in the water may become toxic to eggs and juveniles. Adverse weather conditions such as snowmelt, or heavy rain can be associated with increased levels of metal ions in the water so pH should be tightly controlled at this time.

Optimum water quality parameters are shown in Table 1.

Stocking density

High stocking density can have detrimental effects on welfare and performance. Optimum stocking density will vary between hatcheries depending on facilities, equipment and other variables. Each producer should establish their own optimum stocking density based on welfare and performance, and on available equipment following manufactures guidelines.

Eyed eggs can be stocked at 10,000 to 80,000 per m^2 surface area without reduced hatching rates, depending on facilities and equipment. As stocking density is increased care should be taken to ensure that welfare of alevins during hatching is not compromised.

For optimum welfare, alevins and fry should be stocked at less than 10kg per m^3 after hatching and up to 1g of weight, although field results show that higher stocking densities can be used without effect on post-hatch survival.

Lighting

Eggs and Alevins should be kept in darkness or low-intensity light. Lighting can be increased as alevins begin to swim-up to promote feeding. Turning on and off lights should be done incrementally to reduce stress.

Samples

Water samples should be taken daily from different parts of production and stored in a refrigerator for 14 days for analysis if problems occur.

Table 1. **Water quality parameters for Atlantic salmon eggs and juveniles**

Parameter	Ova	Alevins	Fry
Water Temperature °C	1-8*	1-8**	2-14
Oxygen mg/ml	>7.0	>7.0	>7.0
Oxygen Saturation %	>90	>80	>80
Carbon Dioxide mg/ml	<6.0	<6.0	<15.0
pH	6.2-6.8	6.2-6.8	6.2-6.8

* Triploid eggs are liable to increased levels of deformity if incubated above 6°C.
** Water temperature can be slowly and incrementally increased to 10°C 10-14 days before first-feeding.

Sources: RSPCA and Benchmark Technical team

SECTION 2

BIOSECURITY

Eggs and juvenile salmon are susceptible to many pathogens and biosecurity is the set of procedures designed to prevent pathogens entering the hatchery.

There should be a strict visitor procedure restricting entry of personnel into the hatchery with changes of protective clothing, footwear and hand washing and sanitisation at entry/exit to each biosecure area. Separate clothing and footwear should be used for each biosecure area of the site.

Water should be filtered at entry to the hatchery. Water sterilisation using UV or ozone can be used to prevent pathogens from entering the hatchery. Water sterilisation procedures need to be defined for each hatchery and water source, and equipment manufacturers guidelines followed to ensure the effective operation of equipment without risk to fish or operators.

Equipment

Equipment should be dedicated to each biosecure area, and if equipment movement is essential then thorough cleaning and disinfection should be carried out. There should be thorough cleaning and disinfection of facilities and equipment between production groups.

The hatchery cycle means that each section passes through an inactive period where equipment can be cleaned, repaired (if necessary) and disinfected well before the eggs or juveniles arrive. All equipment should be checked for function and breakage, cleaned and disinfected well in advance of arrival of stock.

It is essential that the system should be filled with water and run at operational flow rates for at least three days before reception of eggs.

Egg disinfection

Sanitary regulations require that eggs are disinfected after fertilisation and before packaging. Boxes and eggs can be disinfected when received in the hatchery. Eggs are usually disinfected with an iodine disinfectant designed for salmon eggs such as Buffodine used in accordance with manufacturers instructions and within shelf life.

SECTION 3

EGG RECEPTION

It is very important that everything is prepared in advance of egg reception. It is essential that enough trained employees are at the workplace, all necessary equipment is carefully cleaned, disinfected, thoroughly rinsed of all disinfectants and cleaning agents, and that a biosecure entry point for eggs is identified.

On most occasions, Benchmark sales or technical staff will attend the delivery to assist if required to check the size and condition of eggs, delivery volumes and temperature log during transport.

Eggs need to be moved from packaging into incubators in an organised way, with minimum physical stress to the eggs. Care should be taken to avoid physical or temperature shocks to the eggs. It is good practice to check paperwork and make detailed records of the transfer of boxes to incubators within the hatchery.

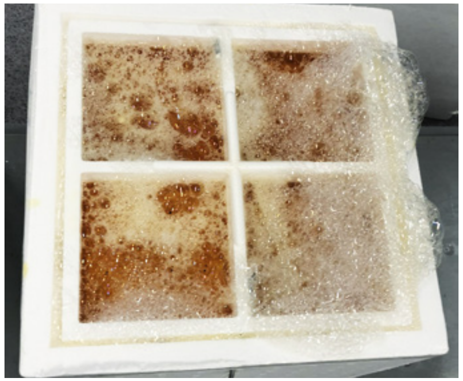
Example of a procedure for disinfecting packaging and eggs:

1. A standard procedure should be developed for each hatchery depending on layout and equipment. This procedure follows general steps which should result in a biosecure transfer of eggs into the hatchery.
2. The outer surfaces of the boxes should be regarded as unclean. Wipe off the outside with a suitable iodine-based egg disinfectant solution, such as Buffodine, prepared according to manufacturer's instructions. Only the disinfected innermost boxes should be taken into the hatchery.
3. Measure temperature of the eggs so that water temperature during disinfection can be adjusted preventing temperature shock to the eggs. Eggs will usually be transported at a temperature of 2-5°C. Sudden exposure of eggs to temperatures of + or - 2°C may cause premature hatching.
4. Transfer eggs to hatching system.
5. Clean and disinfect arrival area. Dispose of boxes according to local sanitary and environmental routine.

Eggs are disinfected just prior to packing, and disinfection of eggs during reception on site should not be needed. If egg disinfection is still required, the following steps could be included in the example procedure between steps 3 and 4:

- Add a suitable disinfectant solution, such as Buffodine, to the transport boxes or other suitable container so that the eggs are fully immersed (see Figure 1) for 10 minutes.
- Gently flush eggs after disinfection with water (avoiding temperature shock) before transferring in to hatching system.

Figure 1. **The use of disinfectant solution**



SECTION 4

INCUBATION OF EYED EGGS

Temperature

Water temperature in hatching trays or troughs should be adjusted as close as possible to the transport temperature (2-5°C). Water temperature can then be slowly adjusted to increase or decrease the rate of development and advance or delay hatching in the range 2-8°C (2-6°C for triploids). Water temperature should not be adjusted by more than 3°C per day. The increase should be done in an incremental manner. Sudden temperature increase can induce premature hatching.

Temperatures above 8°C (6°C for triploids) during egg incubation can increase the level of skeletal deformities.

At temperatures below 5°C development is faster than predicted by the degree days, and hatching may be advanced — see *Terminology* at the end of this manual or use the online hatching calculator to obtain a more accurate date for hatching.

Water Flow and Incubation

It is good practice to be able to observe the development of all eggs during incubation. In most cases, this will require placing less eggs in each incubator than the maximum limit indicated by the manufacturer. This will also make egg cleaning easier in the trays.

1 litre/minute/litre of eggs is an optimum flow rate for water. Slower flow rates may result in reduced survivability due to poor gas exchange. Higher flow rates can produce excessive turbulence that will disturb the eggs, causing reduced survivability.

Light

During incubation, eggs should be kept in darkness or dim light.

Hatching Environment

Eggs are usually placed on a screen or grid, which has holes that are big enough so the newly hatched alevins can swim through and access the substrate below in the bottom of the hatching system.

SECTION 5

HATCHING

The hatching embryo is vulnerable to several environmental factors. It is important that hatching eggs experience optimum temperature, light and water quality to minimize stress resulting in high numbers of viable alevins.

Temperature

Atlantic salmon eggs will typically hatch between 480-520 degree days and hatching will last for 3 to 4 days.

Hatching date and duration will be affected by water temperature during the incubation period. In cold water (1-5°C) hatching can often commence up to 50 degree days earlier and can be extended over a longer period — see *Terminology* at the end of this manual.

Suboptimal water quality and fluctuations in water temperature and oxygen level may result in a premature, stress-induced hatch.

Water Quality

Systems that reuse water within their incubation units can experience a shorter hatching phase.

During hatching, foam derived from protein in the water can present a challenge. During hatching it is very important to keep the incubator screens clear ensuring optimal and stable water exchange.

Gas

Total gas should be measured regularly during hatching and flow rate adjusted if problems are experienced. Total gas values above 100% can cause problems for alevins. In RAS systems, special attention to total gas levels is required because of foam derived from hatching eggs can enter the system.

Light

Newly hatched alevins are sensitive to light and subdued light minimises stress. Gradual light changes from dark to light, and vice versa (i.e. dawn-dusk programmes) also result in lower levels of stress.

SECTION 6

ALEVINS – PRE-FEEDING

Alevins are sensitive to stress and handling. A balance must be struck between handling frequency and duration (which causes stress to the alevins), and hygiene (removal of egg debris and non-viable hatchlings).

Deformed and dead eggs/fry should be carefully removed at least twice per week to prevent the development of fungus. More frequent removal may be required in cases where there is lower hatchability.

Sub-optimal water quality and stress can cause deformed, distended and/or cracked yolk sacs characterized by orange fat droplets on the water surface. Fry with such changes will not survive.

Mechanical damage (handling, fast water flow, etc) is often associated with white bodies in the yolk sac due to coagulation of yolk.

Alevins can be held in a water temperature range of 2°-8°C to control development. Groups held at the lower and higher end of this range may be more variable. As alevins approach first feeding, the temperature in the last 10 to 14 days can be slowly increased up to 10°C (maximum 3 degrees per 24 hours) to reach the temperature required for desired growth.

SECTION 7

FIRST FEEDING AND FRY

An effective first feeding phase plays a crucial role in the future growth and health of a stock. Establishing a good appetite and feeding response makes feed management more effective at later stages.

As with many animal husbandry situations, close observation of fish behaviour in the days before first feeding will indicate when the population is ready to begin feeding. At this time alevins are usually moved to larger tanks where feeding should begin immediately after transfer.

The fry should be introduced to feed between 850-900 degree days after fertilization (370-420 degree days after hatching). Feeding can be initiated when yolk sacs are empty, in practice when 90% of the alevins have absorbed 85-90% of yolk sac.

Small groups of alevins can be observed in the tank or tested in suitable containers for feeding and swimming (“swim up”) behaviour. An ascending temperature profile after transfer and during first feeding, can be used to develop appetite. Alevins will be stimulated to start feeding and develop good appetite by offering feed immediately after transfer and by gradual increase in water temperature. Temperature can be increased by 2°C at transfer, followed by 1°C per day as feeding behaviour develops up to a maximum of 14°C.

During the first feeding phase it is a possibility to retain some substrate from the hatching phase to allow alevins to exhibit natural sheltering behaviour during the transition to active schooling and feeding. This can reduce stress and prevent the fry clumping around the screen outlet. As feeding behaviour develops in the group, the hatching substrate can be removed allowing proper tank hygiene procedures to begin.

Be aware that use of hatching substrate will have an adverse effect on the water quality in the tank when the fry show high feeding rate. A flat screen on the tank bottom may need to be surrounded by a barrier or “hat” until the fish are all feeding. The hatching substrate should be removed as soon as the fish do not require it for shelter to allow optimum water quality.

Feeding

- Hand feeding allows observation of individual groups in early stages of appetite development to ensure that each group is feeding well before moving to automated feeding systems.
- It is especially important to observe the fish carefully during the first 3 weeks of feeding. During this period the fish's appetite is changing rapidly, and underfeeding can lead to aggressive territorial behaviour, resulting in damaged eyes, operculum shortening and/or fin damage.
- It is important to have a good spread of the feed in the tank, with good water flow, speed and direction controlled by nozzle jets. Uneven distribution in the tanks can lead to aggressive behaviour.
- First feeding pellets should float on the surface before sinking gently with minimum amounts of disintegration, to allow alevins to observe feed pellets on the surface and descending slowly therefore stimulating feeding activity.
- Depending on the size and shape of the tank water level, the number and type of feeders, drop height and angle of the pellet when it meets the water can be adjusted.
- Feed supplier should be prepared to provide suitable pellets giving optimal nutrition, feeding and feed management for first feeding fish.

Stocking Density

As feeding behaviour develops, the alevins move from resting on the bottom or in substrate to active shoaling and feeding. Stocking density should therefore initially be managed by surface area and then by volume taking welfare and performance into account. Alevins can be stocked at 10,000 to 20,000 per m^2 without loss of performance depending on equipment. As stocking density is increased care should be taken not to compromise welfare.

Water Exchange

During first feeding, it is important to have control over the water exchange rate. An exchange rate of 100 minutes (60% per hour) should adequate for first feeding at stocking densities described above. Water quality (O_2, total gas) should be monitored to control exchange rate.

Temperature

Optimum growth rates for fry are usually seen between 11-14°C. Groups held at the lower and higher end of this range may be more variable.

Health Challenges

Alevins can be subject to challenge from various pathogens including bacteria, viruses and parasites. Each producer should work with their veterinary adviser to establish a health monitoring and management plan specific to each site.

TERMINOLOGY

Development and Degree days (d°C)

Development and growth in fish embryos (i.e. eggs), juveniles and adult fish is temperature dependent. Degree days allow development to be monitored when temperature varies due to seasonal or management variation:

Degree Days = temperature (°C) x day.
Example: 7°C x 10 days = 70 d°C

Degree hours have also been used to calculate the hatching time for salmon eggs.

Biological development in Atlantic salmon eggs at temperatures lower than 5°C is quicker than the degree days would suggest. Observations in hatcheries have shown that the biological degree day at temperatures below 5°C is related to the actual temperature as shown in Figure 2.

At temperatures above 5°C, actual degree days will be the same as the biological degree days.

pH

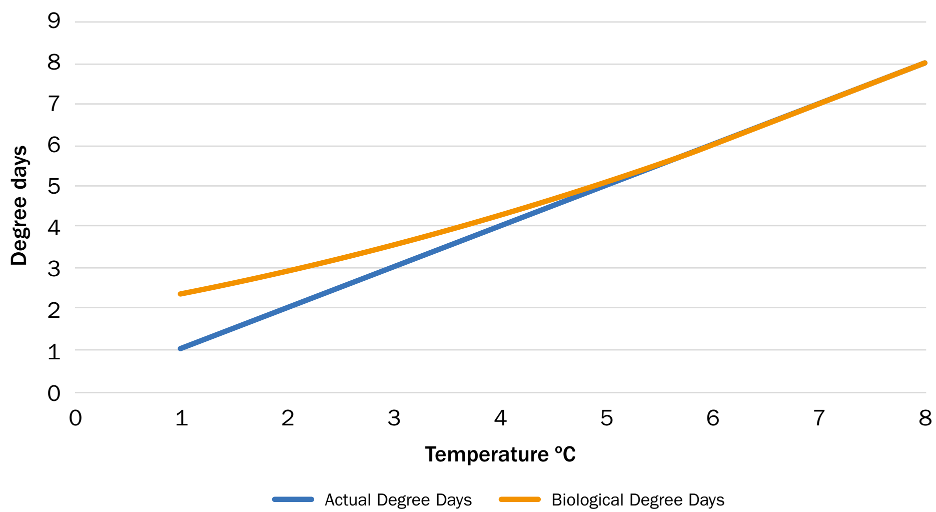
A measure of the acidity of water. Observed changes in pH can indicate changes in water quality due to biological or environmental reasons.

Total Gas

Total gas shows the sum of all gases dissolved in the water measured using a total gas meter.

Total gas should not exceed 100%. This can lead to gas overload and the formation of gas bubbles in the blood of the fish (supersaturation) and increased disease susceptibility.

Figure 2. **Relationship between actual degree days and biological degree days of Atlantic salmon eggs at temperatures between 1 and 8°C**



FURTHER READING

Welfare Indicators for farmed Atlantic salmon: tools for assessing fish welfare. Noble et al (2018). https://nofima.no/wp-content/uploads/2018/11/FISHWELL-Welfare-indicators-for-farmed-Atlantic-salmon-November-2018.pdf

RSPCA welfare standards for farmed Atlantic Salmon. RSPCA, Feb 2018. https://science.rspca.org.uk/sciencegroup/farmanimals/standards/salmon

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