Training Manual for Small-Scale Rainbow Trout Farmers in Net Cage Systems on Irrigation Dams with Reference to Production, Fish Health and Water Quality

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Training Manual for Small-Scale Rainbow Trout Farmers in Net Cage Systems on Irrigation Dams with Reference to Production, Fish Health and Water Quality

by

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INTRODUCTION

This training manual for fish farmers provides guidelines for dealing with water quality and improving the success of rainbow trout farming in net cage systems on irrigation dams. Its aim is to provide a quick reference to procedures and practices for the farmer. Furthermore, it will contribute to the production of quality fish and the maintenance of environmental integrity. The manual has been written to address aspects of farming that requires hands-on management, namely, site selection, operational procedures (e.g. water and feed management), monitoring and evaluation. It also gives the contact details of persons involved in the aquaculture sector who could assist with inquiries. Fish farmers have to strive to be proactive in management and apply better practices to avoid critical situations that might lead to inferior quality of production or huge fish mortalities. Such occurrences could have a negative effect on the viability of the operation.

1. SITE SELECTION

Good site selection is very important for successful net cage trout farming. Once a good site is chosen, all efforts can go into good production management and crises can be avoided completely. The general requirements of a good production site are:

- Proximity to the hatchery to ensure that the juvenile fish (fingerlings) can be delivered to the net cage in perfect health;
- Adequate security to limit theft and vandalism;
- Good access to the water body to facilitate easy transfer of the juveniles to the cages, safe transport of feed and equipment to the cages, and a safe and fast harvest to ensure the good quality of the product;
- The processing industry should be near enough to maintain a cold chain and allow the delivery of a fresh product;
- The minimum depth requirement of the dam should be 5 m to ensure sufficient free space beneath the cages. However, much deeper dams would be preferable for it reduces the long-term build-up of waste underneath the cages and its effects on the dam water quality.

Next to these general considerations, the most important issue is the water quality conditions of the dam chosen for production. Crucial water quality factors for site selection are:

- Temperature
- Oxygen levels
- Ammonia levels
- pH

Good water quality influences fish growth (with faster growth in a good quality water environment), the occurrence of diseases and the taste and colour of the fish. Below, detail is provided on the above-mentioned water quality parameters for a healthy water environment for the fish.

1.1 Temperature

Trout generally grow optimally between 8 and 18°C. Temperatures higher than 21°C will cause trout to stop feeding and will create other problems, such as increased risk of diseases and likely oxygen problems (mainly caused by too many microscopic algae in warmer high nutrient water). As soon as temperatures reach 21°C and above, special care must be taken to prevent mortalities and the on-set of algae taint. Algal taints are caused by the increase in blue-green algae numbers triggered by higher temperatures and nutrient availability. The algae release chemical compounds (e.g. an earth-smelling substance, geosmin) that are absorbed by fish, which changes the taste of the fish meat.

1.2 Oxygen levels

The oxygen levels must be 5 mg/L and above at all times. Oxygen problems are largely caused by microscopic algae (small algae, 0.1 mm or smaller, that cannot be seen with the human eye – refer to Figure 1 below.). These algae produce oxygen via photosynthesis (like all plants) as long as there is enough sunlight and consume small amounts of oxygen during night time respiration. With normal levels of these algae, there will be no problems. If, however, the abundance levels of these algae increase, the levels of oxygen during night time can become lower than 5 mg/L and the farmer will have oxygen problems the following morning. Secondly, if large amounts of small algae die suddenly (natural periodicity, cloudiness, shady weather conditions, application of algaecides), aerobic bacteria will grow massively to help decay the dead algae and will consume oxygen. The oxygen levels in the dams will decrease rapidly and cause stress to the fish.

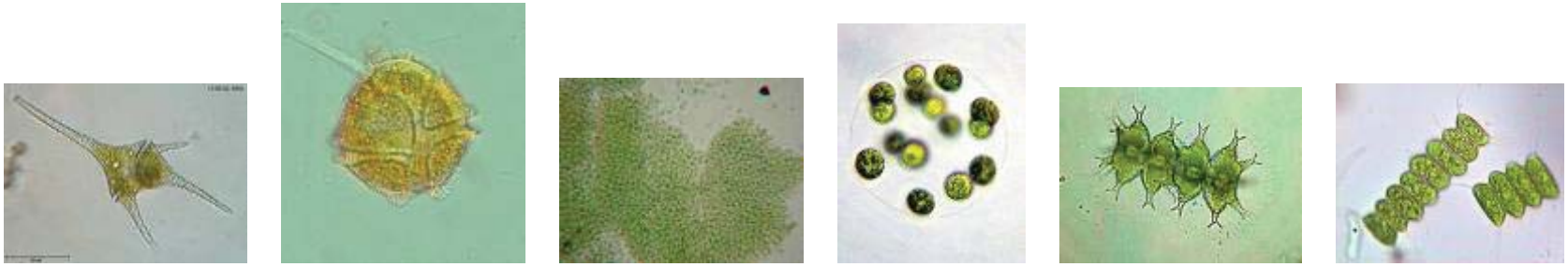


Figure 1: A few phytoplankton species found in water bodies of the Western Cape (Ctrl+Click to follow link).

1.3 Ammonia levels

Ammonia is an inorganic component of nitrogen in water. Unless there is a direct inflow of ammonia or the water is in very anoxic conditions (not enough oxygen), most nitrogen in the water will be present as nitrate, which is not harmful to fish. Ammonia occurs in a toxic (free ammonia) and non-toxic (ionised ammonia) form; the toxic form is usually less than 10% of the total ammonia concentration, but can increase with high pH and temperature levels when more of the ammonia is present as toxic ammonia. Ammonia levels will mostly not create problems in dams unless they are very shallow (5 m or less) and with a low annual turnover rate of less than one

1.4 pH

The pH tells us if a dam is more acidic or alkaline. A pH of 7 is neutral and trout can tolerate pH levels of 5 to 9. In most dams in the Western Cape, the buffering capacity of the water against changes in pH is very low. The most important factor to increase pH levels is again the growth of small algae. Excessive abundance of these algae can increase the pH levels in especially small farm dams to levels higher than 9 during daytime (especially in the afternoon) due to the removal of carbon dioxide during the photosynthesis process. These levels will put fish under stress.

Most water quality problems with cage production, such as oxygen depletion, high ammonia levels or high pH levels, are very closely linked to the abundance of microscopic algae; the occurrence of which depends on the amount of nutrients (nitrogen and phosphorus) in the water. These nutrients enter the dam (see Figure 2 & 3) via:

- The source water (inflow);
- Together with sediments during heavy rainfall events (runoff); and
- Giving feed to fish during the production cycle.

Inflow:

Surface runoff from vineyards, orchards, Fynbos vegetation

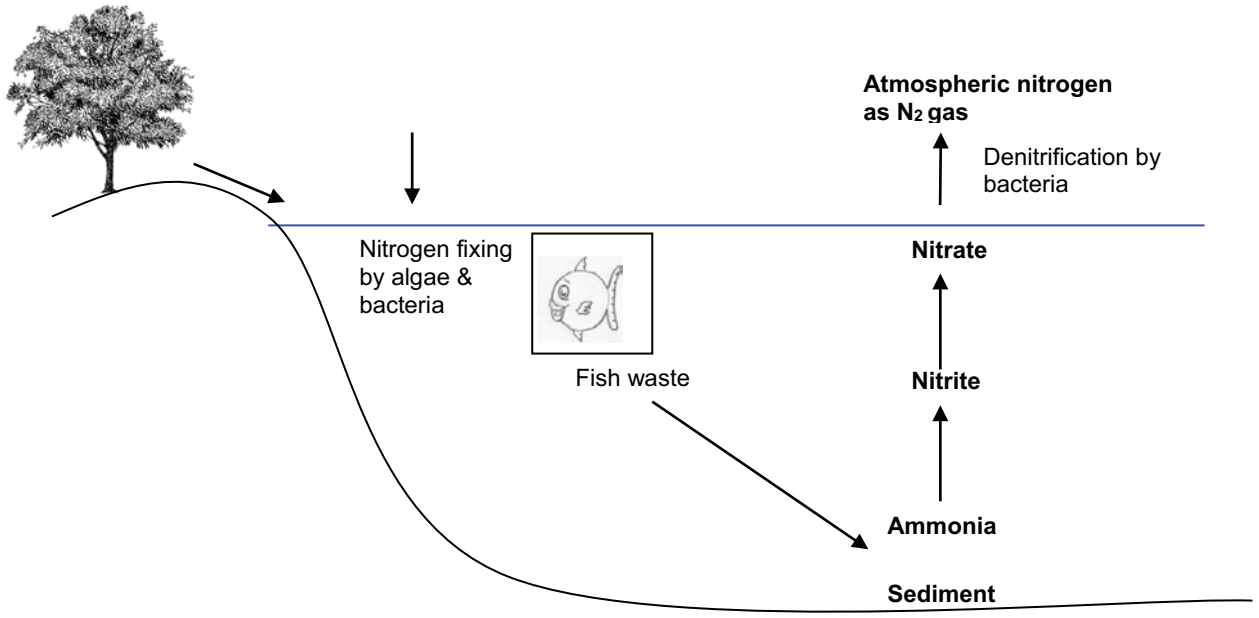


Figure 2: The nitrogen cycle in farm dams of the Western Cape

Inflow:

Weathering rocks
Phosphate fertiliser source
Surface runoff from vineyards, orchards, Fynbos vegetation

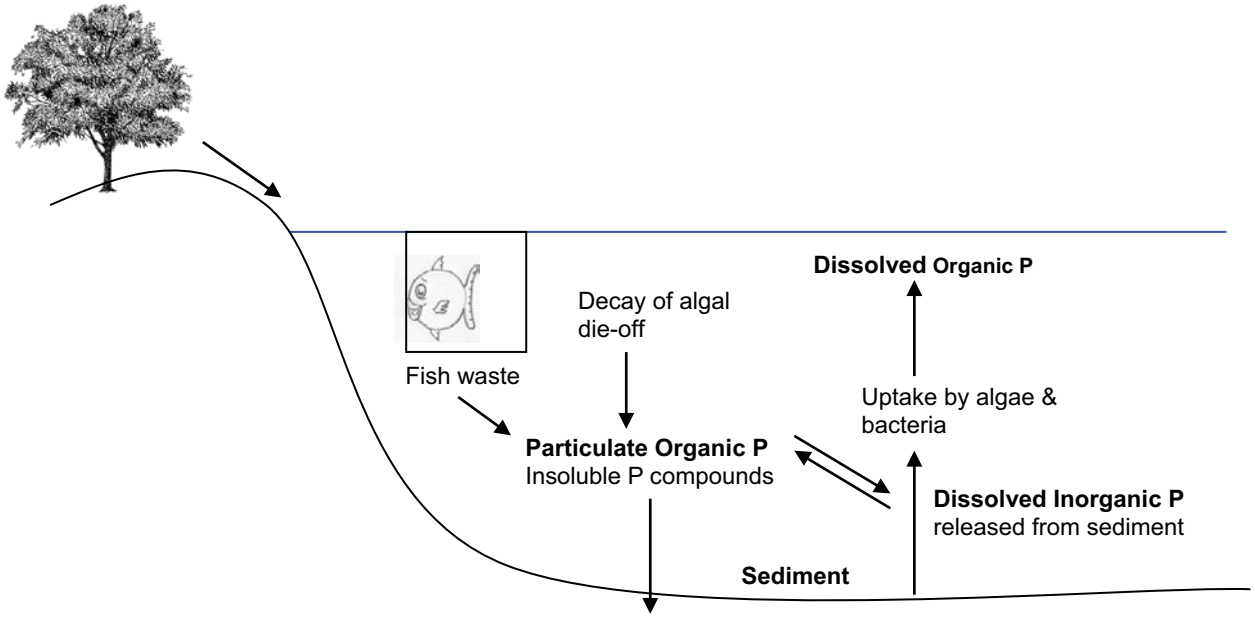


Figure 3: The phosphorus cycle in farm dams of the Western Cape

1.5 Morphometric information

The most important factor of nutrient introduction during fish farming is via the feeding management. The more feed is wasted (not eaten by the fish); the more nutrients can accumulate in the water and cause problems immediately and for many years to come (also see section 2b on feed management). A good trout cage site should therefore be a site that minimises the build-up of nutrients. This can be achieved by selecting sites with a nutrient poor water source, a sufficient water volume to dilute the nutrients introduced by aquaculture and a sufficient flow-through of water. The smallest dam size (expressed in surface area) that will allow production without oxygen depletion risks is suggested to be 3 ha. The minimum requirement to avoid long-term accumulation of nutrients at the bottom is 7 ha and a flow through of water of more than once the full supply dam volume per year. From a precautionary principle perspective, a minimum size of 9 ha (300 by 300 m) and water exchange of at least once the dam volume per year would be recommended. Drinking water dams should be avoided completely, especially if water is extracted from the bottom of the dam. Unless there is sufficient water exchange (more than 3 to 4 times the total dam volume flows into the dam per year), the risk of tainted drinking water (hydrogen sulphide, algal taint, fish faeces) is very high.

The following morphometric information for the dam should therefore be known:

- Water source and other catchment users;
- Surface area (in ha);
- Water volume of dam at full supply level;
- The volume of water that is flowing into the dam (or out of the dam) per year.

Water quality decision-making tool for optimum site selection

The water quality of a dam and the source water must be tested before operations can start. Therefore, a sample of the dam has to be taken from the centre of the dam (not the shore!). The best time for a sampling (of a new dam and the monitoring of established sites) in the Western Cape would be November to January. Water near the surface (better 1 to 2 m) and from the near-bottom of the dam should be sampled (by means of a water sampler). These samples should be tested for oxygen, pH, total nitrogen, ammonia and total phosphorus for the surface sample and oxygen, pH and, ammonia for the bottom water. The initial water quality prior to aquaculture production should be as follows:

- Sufficient oxygen in the surface water (7 to 12 mg/L) – too high would demonstrate excessive phytoplankton growth and increase the risks of oxygen depletion, when phytoplankton assemblage dies off;

- Surface pH preferably lower than 8 (between 5 and 8), and the difference between surface and bottom water pH less than 1.5;
- The ammonia levels at the bottom should not exceed 1 mg/L;
- The total phosphorus levels of the surface water should not exceed 50 µg/L (0.05 mg/L);
- The ratio of TN:TP should exceed 20 (to avoid algal taint risks);
- Good visibility > 50 cm (obtained with Secchi-disc reading).

2. OPERATIONAL PROCEDURES

a) Water quality management

Water quality in irrigation dams, prior to aquaculture, is influenced by the agricultural runoff, domestic or industrial release, storm water inflow, and fertilisers and spraying regimes present on farms. With aquaculture enrichment can only take place due to the dissolving and decomposition of excess or uneaten feeds, fish faeces and dead fish. Once a good site has been selected according to the guidelines provided above, the fish farmer should minimise the influence of production on the water quality. The practices and procedures to achieve good water quality are discussed under feed management and production activities.

b) Feed management

Feeding is one of the most important components in intensive fish production. In many such production systems almost 60% of operational cost is feed. The profitability of the project is reliant on good feed management, optimal utilisation and minimal wastage. Three important aspects to consider are: feed quality from suppliers, storage facility and feeding procedure. Here are a few guidelines to optimise feeding management:

- Do not buy feedstock supplies for more than 4-6 weeks.
- Store feed in a cool dry place with good ventilation. Store feed on a pallet away from a wall where moisture might be present.
- Ensure that the storeroom is free of rodents and other pests that might contaminate feed stocks.
- Choose the correct grain size and feed type according to the growth phase in the life cycle of the fish.
- Follow the prescribed feeding table (can be adapted to feeding behaviour; record all changes to the table implemented).
- Feeding programmes are supplied to all fish farmers.

- Be careful not to overfeed. Maintain correct feeding procedures, such as feeding time of day, tempo, feed distribution in cages and frequency.
- Observe the fish behaviour before, during and after feeding and adjust feed according to the behaviour.
- Observe behaviour and act upon any unfamiliar reactions, e.g. fish eat less than previously.
- The addition of carotene has to be administered 8-10 weeks before envisaged marketing or when fish reach of the marketable weight, e.g. if fish are marketed at 800g, fish should receive carotene at 400g.
- When the water is murky, especially after heavy rains, the visibility of feed decreases and feed has to be given very slowly to enhance utilisation. Smaller amounts can also be given on more occasions during the course of the day.
- Stop feeding when fish response is limited and only resume feeding when response improves. Prescribed quantities that were lost can always be included in future sessions to bring the programme up to date.

The growth tempo of the fish has to be monitored throughout the season. Any deviation in expected growth could be an indication of problems associated with feeding, water quality or diseases. Bear in mind that disturbances caused by humans or animals can also induce stress on animals and lead to slow growth. The procedure to conduct a random test ("steekproef") is indicated below:

What equipment is required for a test sample?

- Writing pad
- Scale (0-100kg)
- Black refuse drums (50-80 liters)
- Safety fish nets to prevent escapees
- Scoop net ("skepnet")

Procedure for taking a test sample

- Starve fish for 24 hours before the sampling.
- Sample one cage at a time. Drive fish together by gradually making the net cage shallower to a depth of 1-2 m.

- Split the cage by pulling a rope across under the cage so that most of the fish are trapped on the side where the sampling will be conducted. Do not throw feed to attract fish for netting and sampling. This will present inaccurate data for only the biggest and strongest fish will reach the feed first.
- Place the scale and drum on a safety net to prevent fish that jump out of net or drum falling into the water.
- Fill drum with water and place on scale. Zero the scale. Scoop fish into the drum at weights of 10 kg for fish 150-500g and 20 kg for fish 500-1000g.
- Record the weight of the fish in a table (see Table 1)
- Release fish into cage by slowly counting the fish. Let both persons who handle the drum, do the counting and confirm afterwards. If numbers do not correlate, ignore the sample and repeat. It is very important to record the weight of fish accurately and do the counting correctly to obtain a reliable average weight.
- Repeat procedure until approximately 5% of the population number has been sampled.
- Always treat fish very carefully for stress is induced every second that fish are out of water. Complete sampling as quickly as possible and lower the nets to the original depth so that the fish can swim freely in cages.

Table 1: Example of a data set with fish weights (biomass) and number of fish.

Sample	Biomass of sample (kg)	Number of fish in sample
Sample 1	10.75	23
Sample 2	9.98	21
Sample 3	10.23	19
Sample 4	9.65	24
Sample 5	10.12	18
Totals	**50.73**	**105**

Calculation of average weight and total biomass

Calculate an **average weight** for the cage by adding up the weights of every sample and divide it by the total number of fish counted: **Average weight**: 50.73/105 = 483 g.

Calculate **total biomass** by multiplying the average weight with number of fish in cage:
Example: 483 g x 3390 fish in cage A = 1637 kg

Calculate the feed conversion ratio (FCR):

Calculate the FCR by dividing the weight gain of fish biomass since the last sample by the feed consumption for that period. For example, if the last sampling was on 31 March and the recent sampling on 30 April, the feeding period was 29 days and 350 kg feed was used. Biomass at 31 March was 1330 kg and on 30 April it was 1637 kg, thus weight gain was 307 kg. (refer to Table 2)

Table 2: Biomass calculations.

Date of random test (steekproef)	Feeding period (days)	Amount of feed used (kg)	Biomass at sampling (kg)	Weight gain since previous test sample (kg)
31 March			1330	
30 April	29	350	1637	307

Thus conversion ration = 350 kg feed / 307 kg of fish = 1.14
It implies that 1.14 kg feed was required to add 1 kg of fish weight
Thus the FCR is 1.14:1
Compare results with the suggested growth curve according to the feeding programme. Investigate management if the real growth is more than 5% lower than the expected growth rate. Test sampling provides an ideal opportunity to evaluate the overall condition of the fish and to observe if any wounds, severed fins or, blindness are present. Report any of these conditions to ensure prompt reaction. Evaluate feed conversion ratios on a monthly basis. Do not overreact. First determine the extent of abnormalities and then contact supporting technical staff to assist.

c) Production activities

Purchasing of juvenile fish (fingerlings)

The purchasing of good quality fingerlings is an important aspect of successful production. The following points are guidelines to consider:

- Determine the selling price beforehand and compare with other suppliers.

- Inspect the general appearance of the fish, number of individuals, general sizes and age, and when it was purchased.
- Make sure all weighing and calculations were done correctly for the purchaser pays the supplier per kilogram fish loaded. The total mass and number of fish are important for future growth prediction and FCR calculations.
- Stock a sample of 100 to 200 fish and monitor it for approximately one week. If no negative behaviour is noticed, the rest of the fish can be stocked. This procedure will help to evaluate the water quality of the dam and minimise the risk in losing fish when the dam is fully stocked.
- Reach an agreement with the supplier on the method and terms of payment.

Transport of fish to grow-out sites

Preparing the necessary equipment and fish, as well as continued monitoring during transport, is very important to ensure that the welfare of the fish is maintained and that the fish will be delivered in good condition. Pay attention to the following:

- A permit from Cape Nature is required for the transport of fish. This has to be obtained at least 14 days before the planned transport.
- Prior to transport, fish have to be starved for 24-48 hours.
- Transport equipment can be rented from commercial farmers. Ensure all the equipment is in good working order.
- Carry an extra oxygen tank for emergencies.
- Load the transport tanks according to suggested densities: 1.0 – 1.2 kg of fish per 10 liters of water.
- Assess the oxygen levels and the condition of the fish in the tanks after the fish had been loaded and just before the transport of the fish begins.
- Ensure that the piping is not obstructed by the tanks (1000 liters of water weighs 1 ton!).
- Check the weather forecasts a few days before transport. In warmer weather additional care is required with the transportation of fish.
- The driver of the transport truck has to make sure that the tyre pressure is correct and should drive cautiously at all times.
- Inspect the tanks every 20 – 30 minutes during transport. Make sure the oxygen levels and the water temperatures are in order. If the fish appear lackluster or are lunging at the water surface for air, then it is an indication of low oxygen levels and additional oxygen has to be released into the water. The fish must be energetic and move around with ease (Figure 3).

Figure 3: Delivery of fingerlings to grow-out sites.

- Try to maintain a balance between transport tank water and the dam water in terms of temperature and chemical composition by mixing 50% of the tank water with dam water.
- After the fish have been stocked in cages, wait at least 12 hours before the first feeding.
- Monitor the fish closely for the next 24-48 hours after the fish had been stocked.
- Always bear in mind that fish are transported at own risk, or as otherwise agreed.

Harvesting

The correct harvesting method and the maintenance of a cold chain from the production site to the processing factory are important for fish quality. The following guidelines are provided:

- Starve the fish for 3-5 days prior to harvesting to empty the stomach content. This will prevent any off-taste and microbial contamination and will ensure better overall hygiene and quality during the slaughtering process.
- Make sure fish are graded in uniform sizes prior to harvest.
- Harvesting of trout is usually during the early summer months, and should therefore start early in the morning when temperatures are still cool (Figure 4).

Figure 4: Harvesting of fish at grow-out sites.

- Fish can be killed by adding an anaesthetic to the water in the harvesting tanks, e.g. commercial AquiS solution. Avoid unnecessary handling that might induce stress as well as causing fish to bruise and lose scales, thus affecting the quality of the produce.
- Store fish postharvest below 5 ºC by covering them with layers of ice or ice slurry.
- Deliver the correct quantities of fish in clean bins to the processor at the time and date agreed upon.
- NB: It is good practice to send a sample of 50-80 kg of fish to the processor for testing prior to the harvest. The sample will be evaluated for meat colour, taste and general appearance. Only after the sample has been cleared, the rest of the fish should be delivered. Furthermore, the fish farmer should also arrange for freezer storage facilities of harvested and gutted fish in cases where it is not possible to deliver fresh fish to processing factories.

Cage maintenance

Frequent inspection and maintenance of the net cages reduces operational costs and improves production efficiency. The following cage maintenance should be conducted on a regular basis:

- Inspect the nets weekly by lifting one side at a time to look for holes and tears that might lead to fish escaping. This could be done on a weekly basis and also during the monthly test sampling and harvesting days.
- Keep nets clean of algae growth by lifting one side and allowing it to wind dry. The dried algae can be brushed off. Clean nets improve water flow through nets and provide oxygenation.
- Remove dead fish immediately. Dead fish also lie on the bottom of the net for a few days before surfacing. Dead fish on the bottom can be removed during routine net inspection.
- Cages can be protected from predators, such as cormorants and otters, by installing an anti-predator net on the outside of the cages suspended to a depth of at least 1 m below the bottom of the cage.
- Fish mortalities in production systems can occur due to poor water quality conditions, disease outbreaks and wounding by predators. Production sites should be inspected on a daily basis for any dead fish, which should be removed and disposed of in an environmentally friendly manner. Dead fish should be disposed of in a subterranean pit accompanied by a large amount of lime. Lime increases the decomposition of organic matter. Other treatments include incineration of carcasses or the use of acid. All mortalities (single incidents and mass mortalities) should be recorded together with possible causes.
- The data should be supported by behavioural patterns observed on the whole production population.
- The stability and anchorage of cage anchor lines should be checked.
- The safety and integrity of the floatation of the cage structure, as well as the transport float between the cages and the banks of the dam should be inspected regularly.
- Maintain the cleanliness of cage platforms. Platforms should be swept daily to remove old feed, slime from fish and water bird droppings. It can become slippery in wet conditions and water safety regulations for staff should be exercised at all times.
- Any sign of corrosion to cage collars and platforms should be noted. Attach old tyres between the cage structure and the transport float to prevent damage to the galvanising of both structures.
- Structural Investigation of cages, netting and anchor should also be done following the emergency movement of cages (e.g. low oxygen conditions, inclement weather conditions).

The following table (Table 3) can be compiled and completed daily for good record keeping and management.

Table 3: Record keeping of routine cage inspections.

Date of activities	Feeding	Dead fish	Water temperature	Oxygen levels	Fish behaviour	Cage and net inspection	Other

Quality control

Regular quality control is important to the farmer to make sure that harvested fish adhere to the quality requirements set by the processing companies. The market penalises farmers whose fish do not meet the quality standards; communicate with processors regarding current quality standard and requirements. Important quality criteria are listed below (see Table 4):

Table 4: Quality criteria and standards as required by processing companies.

Quality criteria	Quality standard
Fish weight	Minimum is 1 kg (ideal 1.2 - 1.4 kg)
Dress out %	Cleaned with head (85% of round weight)
Dress out %	Cleaned without head (75% of round weight)
Meat colour	Roche scale: (min 28)
Outer appearance	Healthy body with no wounds
Meat quality	Prevent internal bleeding and muscle gaping by maintaining cold chain during harvesting and handling fish carefully at all times
Taste	Algal taint of meat can occur within 24 hours in cage systems. Farmers should conduct regular tasting, at least 4 - 6 weeks before the envisaged harvesting to ensure fish are free of algal taints

d) Disease monitoring; treatment and control

Although disease outbreaks are not common among trout farmers, pathogens that can cause illness and disease are omnipresent in the water environment. Farmers have to ensure that fish maintain a good health status by providing optimal water quality conditions and observing the presence of diseased fish. A short guide to effective monitoring and treatment of the most common disease and health problems with net cage farmed rainbow trout is provided. Good health management starts with purchasing fish from registered suppliers. In cage farming systems there are a number of reasons why problems with fish health and disease can occur. Direct as well as indirect causes include infectious diseases (caused by parasites and bacteria), the effect of the environment (poor water quality), poor management practices and any action/event that causes stress. Stress can be defined as a state produced by an environmental or other factor (stressor), which extends the adaptive responses of the individual beyond the normal range, such that its chances of survival are significantly reduced. Every possible measure should be taken to limit stress on the fish. Care should be taken with the following tasks: transport and movement of fish; handling and grading; and feeding and harvesting. The health status of the fish is a dynamic equilibrium, influenced by three factors: fish (host), pathogen (disease-causing agent) and environment. The relationship is illustrated in the Figure 5 below:

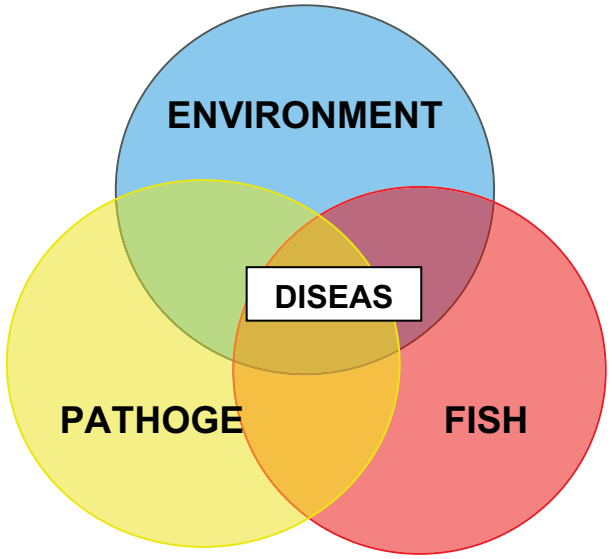


Figure 5: Relationship and interaction of the environment, fish and pathogens.

The equilibrium is delicate and can be influenced by any action performed by the fish farmer as well as any changes that can occur in the environment. This greatly increases the risk of disease situations.

How to monitor, identify and treat health problems and diseases

Monitoring the health and well-being of the fish is a routine management task. Visual inspection/monitoring can be done daily when feeding the fish. A more comprehensive health check should be done regularly (e.g. monthly) and thorough investigation should take place once a disease situation has been noticed.

What do we monitor?

Feed response - e.g. feeding less

Behaviour – any abnormal behaviour should be noted

Breathing/respiration – e.g. are they struggling for air?

Swimming motion – e.g. are they just hanging in the water

Appearance – skin colour, texture, and any visible marks/lesions

Water environment – visibility, oxygen, temperature, pH, ammonia

Mortalities – how many, how frequent?

Why is it important to monitor disease?

Prevention is better than cure. The first step is to ensure that only healthy fish are placed in the cage(s) at the start of the season. Regular monitoring will help to identify problems as soon as they occur, and maintaining and monitoring good water quality (optimum environment) is essential for good health. It makes economic sense to prevent disease from occurring rather than trying to treat a problem, due to:

- Treatments are often expensive (limited range of products for use with food-fish);
- It is time-consuming (including mandatory withdrawal periods);
- Sick fish do not grow that well (poor feed conversion);
- Disease causes losses (lower production); and
- Disease often results in a poor quality product (sold at a lower price).

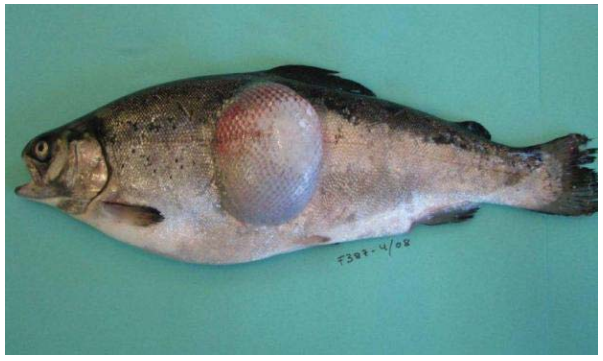
Common signs of poor health or disease:

- Loss of appetite;
- Fish are lethargic (swimming slower or hanging in the water);
- Abnormal behaviour (flashing, jumping);
- Change in appearance (colour fades or fish becomes darker, excess mucus);
- Obvious marks or lesions on the body or fins (damage, ulcers or fin rot); and
- Mortality occurs or increases (dead fish are found more frequently).

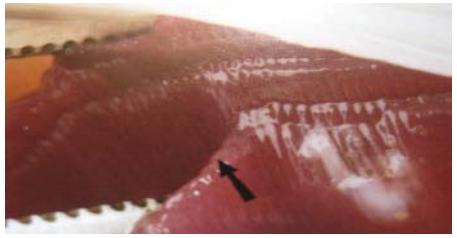
Common diseases and health problems

Bacterial diseases:

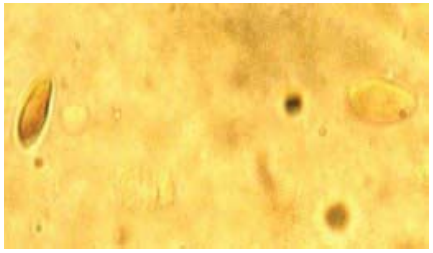
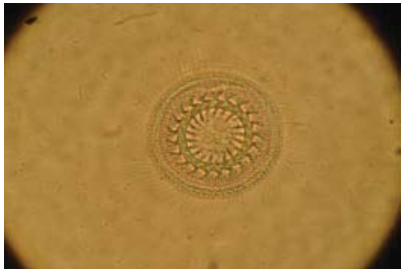
The table below provides picture references to diseases featuring, the disease name, an image of the appearance on fish, when and why it occurs, signs and symptoms, and possible treatment as a means of immediate intervention. Farmers should use the tables to identify diseases and should immediately notify the disease diagnostic and treatment team. Rainbow trout below infected with *Flavobacterium* sp (left) and occurrence of Furunculosis (right)

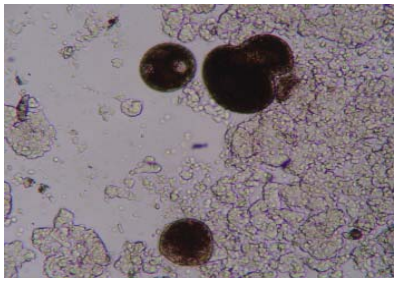


Bacterial diseases:

Disease	Image/Photo	When and why does it occur?	Signs and symptoms	Possible treatment
Bacterial Gill Disease (BGD): *Flavobacterium*		During poor water quality conditions and high temperatures. Also known as Environmental Gill Disease. A secondary infection of gills that were damaged by irritants (solids, ammonia)	Destruction of gill tissue (white, necrotic patches) and visible bacterial mass growing on the gills	Improve environment Coarse uniodised salt Chloramine-T Hyamine®
Fin and Tail rot: *Flavobacterium*		In poor environmental conditions and high temperatures. Readily infects fins and tail subjected to erosion/damage.	Reddening of fins develops into white, eroded areas on the tips of fins/tail.	Improve environment Coarse uniodised salt Chloramine-T
Furunculosis and *Aeromonas*		At high densities, high water temperatures and poor water quality. Readily infects stressed fish and any areas of damage on the body of the fish.	Excessive mucus on the body. Areas of reddening. White patches on skin. Ulcers and pop-eye.	Disinfection for superficial infections. Antibiotic treatment for systemic (internal) infections.

Parasitic diseases:

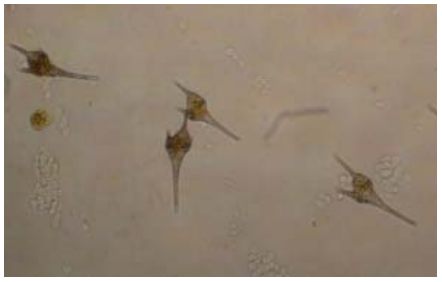
Disease	Image/photo	When and why does it occur?	Signs and symptoms	Possible treatment
Costia	 Small, fast moving parasite – characteristic tumbling motion visible under microscope.	Usually occurs when fish are stressed (over-crowding, poor water quality). Parasite is active in a vast temperature range (2^0C – 29^0C).	Milky haze (grey/white layer) over the body, especially on the sides. Excess mucus. Reddening of skin. Flashing or rubbing. Can cause severe mortality amongst small fry.	Good husbandry Salt Chloramine-T Formalin
Trichodina		Common in environments with sediment build-up and high organic loads. Affects the skin and gills	Flashing and rubbing. Excess mucus. Fin erosion and/or ulceration. Respiratory difficulty.	Improve environment Salt Chloramine-T

White spot (“Ich”)		Very common parasite. Temperature-dependent (occurs below 28^0C). Often attacks stressed and weak fish. Infests the skin and gills.	Flashing and rubbing. Lethargic movement. Excess mucus. Small white spots on the fins and body.	Good husbandry Good water quality and stable temperatures. Formalin

Fungi:

Disease	Image/photo	When and Why does it occur?	Signs and Symptoms	Control
Saprolegnia Cotton Wool Disease	 *Saprolegnia* sp. under light microscopy.	Omnipresent (ubiquitous). Especially in water with high organic loads and dead or decaying fish matter. Part of tail and fin rot complex. Trout more susceptible during spawning season.	Fungus spreads over the body – white tufts with cotton-wool appearance	Improve environment Good husbandry - removal of dead fish daily Limit stress and physical damage (netting, handling)

Other:

Condition	Image/photo	When and Why does it occur?	Signs and Symptoms	Control
Algae blooms	 Algae particles under light microscope.	When perfect growing conditions (enough light and nutrients/food) cause algae to multiply rapidly. Very common beneath cages and in static ponds or dams.	Water turns green, blue, brown or red. Fish struggle to breath (gills get clogged with algae). Some algae secrete toxins that can cause mortality. Algae can taint the flesh and affect the quality.	Manage and monitor algae levels in the dam. Avoid build-up of nutrients under the cages (once the nutrient source has been removed, the algae will die off). Ensure sufficient aeration if algae bloom occurs.

How to treat diseases – safely

- A proper investigation and diagnosis has to be made before any fish can be treated.
- Consider the benefits as well as disadvantages of having to treat the fish.
- Select the most appropriate treatment and method (e.g. medicated feed or bath treatments can be used in cages).
- Ensure that the best possible environment is provided for the fish – if possible use aerators.

- Avoid any further stress (e.g. handling or movement).
- If treating with a new product or for the first time, it is advisable to perform a trial treatment with a small group of fish – to assess their reaction to the treatment and prevent a possible fish kill.
- Do not feed the fish for 24 hours prior the treatment (the digestion process uses oxygen and one wishes to conserve as much oxygen for the fish as possible).
- Ensure your calculations and dosages are accurate (using accurate biomass and volumes).
- Always treat early in the morning (at low water temperatures) and monitor the response of the fish.
- Keep a detailed treatment log – dates, type of treatment, reasons for treating, reaction of fish, etc.
- Always adhere to the recommended withdrawal periods when using chemicals and drugs.

Good water quality is the first provider of good fish health and supports a good immune response by the fish in case of disease occurrence. Good temperature levels (between 8 and 20°C), a pH range around neutral point (pH 5 to 8), low ammonia levels (< 1 mg/L) and high oxygen levels (> 7 mg/L) are therefore the best guarantee for healthy fish. High temperatures favour the occurrence and spread of diseases. There should be an emergency plan for early disease recognition (own monitoring of fish behaviour and appearance), support with confirmation and determination of a fish disease (health inspector) and a list with legally acceptable medication in case of a disease outbreak. In case of an utmost emergency, there should be an evacuation plan into an alternative dam (with no other fish and better water quality conditions), with intermediate treatment. Regular (at least three times a week) inspections of the appearance of the fish and their behaviour should be undertaken. Signs of bad health can be:

- Increased mortality (dead fish);
- Fish swim slower;
- Fish swim near the surface;
- Fish swim on the side;
- Fins change their colour or rot;
- Fish change colouration.

The most commonly occurring diseases found in cages in the Western Cape are:

Disease	Type	Syndrome/Behaviour	Treatment
White Spot	Protozoan (single cell organism)	White patches on body; becomes lethargic; attempts to remove parasites by rubbing on side of tank	Good husbandry Good water quality and stable temperatures. Formalin
Furunculosis	Bacterium	Inflammation of intestine; reddening	Disinfection for superficial infections. Antibiotic treatment for systemic (internal) infections.

3. MONITORING AND EVALUATION

Monitoring of water quality

Cage aquaculture activities have a direct influence on the water quality of the farm dam. Impacts on the water quality are derived from the addition of commercial fish feed, fish biomass and metabolic waste products associated with fish farming. Water is the primary resource that is impacted and should be monitored to recognise any deterioration in water quality. Ideally, the water quality that the production season starts with should be comparable with the quality of the outflow. Water samples should be collected at least once in two months and sent to an SANAS (South African National Accreditation System) accredited laboratory for analysis. Water samples should be taken from both inflows, outflows (when present) and the middle of the dam. Most important, water samples should be taken from the surface as well as from the bottom water layers of the dam. Results should be recorded and compared to previous data to determine whether water quality is deteriorating. Water quality monitoring results should be correlated with feeding rates and biomass to ensure that biomass does not exceed the production carrying capacity of the water resource.

Parameters that need to be considered during analyses include:

- Total phosphate
- Ammonia
- pH

Parameters such as water temperature and dissolved oxygen levels should be carefully monitored daily and during times of transportation.

4. USEFUL CONTACT NUMBERS

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