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Glossary

Acclimatization — A process which takes place when the temperature of the transport water is gradually adjusted to the temperature of water in which the arriving fish are released. When the temperature of the transport water is the same as the temperature of the receiving water, fish can be released without further acclimatization. The **thermal shock** can be particularly dangerous for young fish. Therefore, in the case of several degrees of difference, the adjustment process may take 30–40 minutes. Tempering is a practical United States term for acclimatization.

Aeration — The aeration of water allows for an increase in the number of fish per unit volume of the rearing water. The oxygen content of the water, which is a limiting factor, can be increased by mechanical agitators such as paddle wheels, or by ejectors, air diffusers or blowers. Aeration is a widespread technique for increasing the production capacity of fish ponds and tanks. An additional effect of aeration is that gases, such as carbon dioxide (CO_2) and ammonia (NH_3), are "driven/aerated out" from the water.

Alevin — See definition of **sac fry**.

All female stock — A stock where only females of the progeny are produced through pairing sex-reversed parent fish. In rainbow trout, female specimens grow faster. Another advantage of all female stock is that escaped fish will be less likely to propagate successfully in the wild. Therefore, all female progeny of sex-reversed males and normal females are produced and sold.

Anadromous — Fish that live in the seas but migrate upriver to spawn. Fish that migrate from the river to the sea to spawn are **catadromous** fish.

Annelids — Segmented worms of the **phylum** Annelida to which, among others, earthworms and leeches belong.

Ataxia — A disorder of partial or total inability to coordinate body movement (Guralnik, 1968).

Biofilter — See definition of **biological water filter**.

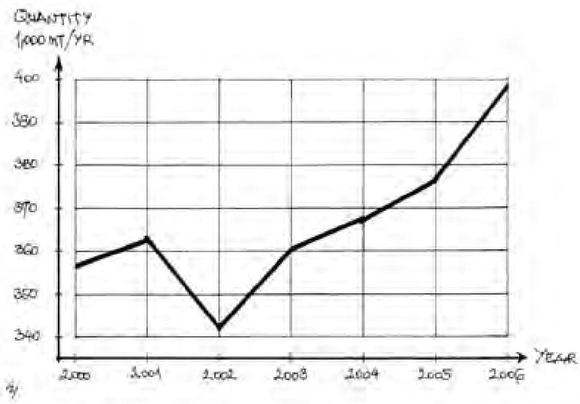
Biological water filter or **biofilter** — A device where bacteria oxidize the ammonium-N. These filters are used, among others, in intensive, industrial-type fish culture systems for removing the ammonia from the recirculated water by nitrifying bacteria. Materials that have a large surface/volume ratio for the settling of bacteria can be used as media for filling the biological water filters. These materials can be sand, stones, nets, plastic beads, lamellas, etc.

BOD — The abbreviation for **biological oxygen demand**. It is the quantity of the oxygen (in milligrams per litre) consumed by bacteria to decompose the organic materials in the water. For easy comparison, the length of the period during which the process takes place is standardized and indicated as a subscript index, e.g. BOD_5 means BOD in five days.

Break-even or **break-even point**	The point when costs and financial benefits are equal. At this point, the production turns from losses into profit or vice versa. In other words, the break-even point is when there is neither profit nor loss on the produced fish. Below the break-even point, fish farming produces a loss, and above the break-even point it produces a profit.
Broodfish (also spelled brood fish)	The carefully reared and selected sexually matured male and female specimens that are kept for propagation. Only from a professionally created and maintained stock of broodfish can good-quality and well-performing progeny be expected.
Carcinoma	Any of several kinds of cancerous growths made up of **epithelial** cells (Guralnik, 1968).
Catadromous	See definition of **anadromous**.
Chemicals	Often, dangerous poisons are frequently used as remedies in fish culture. Therefore, it is important to keep all these chemicals locked away from children. Although the chemicals are found in extremely small concentrations in the water of fish, it is important to emphasize that they can be very harmful for humans and other animals if they come in contact with or consume them.
COD	The abbreviation for **chemical oxygen demand**. The COD is an indicator that shows the oxygen consumption of the chemical process through which all organic and non-organic materials in the water can be oxidized.
Cold water fish	The body temperature of fish depends on the temperature of the water in which they live, because fish are **poikilotherm** animals. There are cold water fishes (e.g. trout) and warm water fishes (e.g. tilapia, African catfish). They do not tolerate water temperature out of their specific range of water temperature. There are also species (e.g. carps) that tolerate both mentioned ranges of water temperature.
Concentrated solution	A recommended quantity of the chemical to cure fish that is first dissolved in a small container (bucket or bowl) before it is diluted to the planned concentration in another larger container or rearing tank. It is a technique that is used to ensure the proper solution and even distribution of such chemicals.
Consistency	The quality of soil that indicates how suitable it is for building a dyke. The more consistent a soil is, the better it serves for building the dyke of a fish pond.
DO	The abbreviation for **dissolved oxygen,** which ensures the respiration of fish. The symbol of the oxygen molecule is O_2.
Duration of development stages	of fish depends not only on the species, but also on the temperature of the water in which they live, as well as on the quantity and quality of consumed food (in the wild) or feeds (in a fish farm).
Effluent	The water that flows out from fish ponds or tanks. It is the collective name of liquid waste and sewage discharged from a fish farm into the wild.
Embryo	of fish develops in the fertilized egg.
Epithelium	The cellular tissue covering surfaces, forming glands, and lining most cavities of the body. It consists of one or more layers of cells with only little intercellular material (Guralnik, 1968).

Exchange rate	of water is the frequency with which water is fully replaced in the rearing device. It can be expressed on a per-day or per-hour basis as shown in Table A10.3.
Exophthalmia	The abnormal protrusion of the eyeballs (Guralnik, 1968).
External feeding	The term means taking natural food or feeds from the environment. External feeding starts when fish larvae/fry are about to finish the yolk sac.
Eyed egg	The development stage of fish embryos when their eyes can first be seen well. The development of eyes takes place in the second half of the incubation period. In this stage, the egg can be safely transported even between countries and continents.
Family	A principal **taxonomic** category below order and above **genus**.
Feeding larvae	See definition of **swim-up fry**.
Fertilized egg	Egg carrying the developing embryo of fish.
Fingerling	A widely used term in fish culture. It refers to the size of a young fish, which is about 10–15 cm (10–35 g).
Fly fishing	See definition of **natural food**.
Feed conversion ratio (**FCR**) or **feed conversion rate** or **feed conversion efficiency (FCE)**	The quantity of feed that produces 1 kg of live fish. Accordingly, the FCR or FCE is a very important indicator of the efficiency of feeding.
Fry	The term for the development stage of fish that starts when young fish gulp air and finishes when the pre-adult form ends. By the end of this stage, all organs have developed including the reproductive organs (testes or ovary), which makes it possible to determine the sex of young fish. The size of young rainbow trout fry is about 3–7.5 cm and 0.5–5 g.
Genus (plural: **genera**)	A principal taxonomic category that is below family and above species. The first part of the scientific (or Latin) name of species refers to the name of the genus, which always starts with a capital letter.
Global production of trout	Among salmonids, trout are the most widely cultured species. Its total global yearly production summarized in the accompanying graph shows a steady increase (FISHSTAT, 2009).

Trend of global trout production



Habitat The living place of an organism or community, characterized by its physical or biotic properties.

Haemorrhage The escape of large quantities of blood from the ruptured blood vessel, heavy bleeding (Guralnik, 1968).

Harmful gases Gases such as carbon dioxide (CO_2) and ammonia (NH_3) are the result of the respiration and metabolic processes of fish. These gases, released into the water through the gills of the fish, can easily accumulate in the water of rearing and transportation devices.

Harmful solid materials Water of rearing tanks contain the uneaten and decaying feeds and faeces. They are harmful because they pollute the water in which fish are reared or transported. Bacterial decomposition of the faeces consumes oxygen and, in addition, harmful gases can be released during the process of decomposition. Their quantities are measured in terms of **BOD** or **COD**. Excess levels of suspended soils (first of all, clay colloids) can also be harmful to fish.

Hibernation A process where the body temperature of a **poikilotherm** organism decreases and its **metabolism** reduces to a minimum. In the case of trout, this minimum is about 2 °C.

Injection of pure oxygen Injecting pure oxygen into the rearing water is an expensive technique used in super-intensive farms where the total weight of trout in unit volume is extremely high (50–100 kg of fish per cubic metre).

Introduction The introduction of rainbow trout makes it one of the most widely cultured fish species. It has been introduced to all continents (Welcomme, 1988).

Ion An atom, or group of atoms, that has gained or lost one or more electrons and hence it carries a negative or positive charge (Sharp, 1990).

Lake trout The common name of *Salvelinus namaycush* in North America, where it is native. It should not be confused with the lake form of brown trout (*Salmo trutta lacustris*), which is indigenous in Europe and also widely called lake trout.

Metabolism The sum of life-maintaining physical, biological and biochemical processes carried out by living organisms. The organisms consume and digest certain materials in order to utilize their energy for maintaining their own activity and to deposit a part of the materials in different locations of their bodies. The discharge of used materials from the organism is the last phase of metabolism (Thain and Hickman, 1980).

Natural food The collective name of those food items that can be found and consumed by fish in natural waters. In general, natural food either grows in the water or falls/drifts into it. In the case of salmonids, the fish also hunt for natural foods that touch the water surface or fly close to it. Dry **fly fishing** is based on this feeding habit of trout.

Non-feeding larvae See definition of **sac fry**.

Pan fish (pan-size fish) See definition of **table fish**.

Permeability Permeability of soil indicates how fast water passes through it. Permeable soils allow water to pass, while impermeable soils do not.

Petechia	A small haemorrhagic spot on the skin, mucous membrane, etc. (Guralnik, 1968).
pH or H^+ ion concentration	Water molecules in nature dissociate to H^+ and OH^- **ions** according to the formula: $H_2O \leftrightarrow H^+$ and OH^-. pH is the negative logarithm of the H^+ ion concentration. This is that figure with which the hydrogen ion (H^+) concentration in the water is expressed. One litre of clean water contains 0.0000007 g H^+. In order to avoid calculations with extremely small numbers, the logarithmic scale is used for the determination of the H^+ concentration. This concentration is expressed on the pH scale of 1–14 (Dévai and Dévai, 1980).
Phylum	A taxonomic category above class and below kingdom.
Poikilotherm (i.e. such as fish or reptiles)	This is normally the state of being cold-blooded; more precisely, having a blood temperature that varies with the temperature of the surroundings.
Ponds	Large but shallow earth structures, which are typically constructed for rearing fish. The fish culture techniques for ponds are based on manuring/fertilization and/or supplementary feeding. In the case of trout farming, small raceway ponds, also called Danish ponds, are constructed and used.
Production capacities	The results of a rainbow trout farm can be doubled if both autumn and spring fry are reared because the same rearing devices can be used twice per year. In this case, not only fry production can be doubled, but also fingerling production. The production of autumn and spring fry is possible because there are some rainbow trout **strains** that spawn in autumn, while others spawn in spring.
Proteins	The prime organic constituents of the body of plants and animals. Only plants and a few bacteria are able to produce their own proteins from inorganic materials. Animals need the proteins of other living organisms in order to produce their body proteins. Many of the farmed animals need specific animal or even fish-origin proteins. There are animals that need less protein (15–20 percent) in their diets, but there are animals that require a high animal/fish-origin protein content (35–65 percent) in their diets. Trout, as they are a predator fish, belong to this latter group of animals. It is also very important to note that the younger age groups of trout require more protein (45–65 percent) in their diets than do older ones.
Raceways	Rectangular concrete or earth structures that are 5–10 times longer than they are wide. In raceways, a continuous water flow ensures the successful high-density rearing of fish.
Rearing devices	The different movable incubation and rearing trays, jars, troughs and tanks made out of a wide range of materials, such as planks, plastic, fibreglass, polypropylene, PVC, **tarpaulin**.
Remedy	See definition of **chemicals** used as remedy.
Sac fry (yolk-sac fry), **alevins** or **non-feeding larvae**	The terms used for the already hatched fish larvae that still carry the yolk sac. There is no **external feeding** because the developing larvae feed internally from the yolk sac.

Salmon	Widely produced salmons belong to the **genera** of *Oncorhynchus* and *Salmo*. These are the seema salmon (*Oncorhynchus masou*), pink salmon (*Oncorhynchus gorbuscha*), chum salmon (*Oncorhynchus keta*), coho salmon (*Oncorhynchus kisutch*), cherry salmon (*Oncorhynchus masou masou*), sockeye salmon (*Oncorhynchus nerka*), chinook salmon (*Oncorhynchus tshawytscha*), Black Sea salmon (*Salmo labrax*) and Atlantic salmon (*Salmo salar*).
SI	The abbreviation for the International System of Units. These units are weight (mass), length, area, volume, capacity, temperature, time, etc., detailed in Table A10.1.
SL	The abbreviation for the standard length of fish, which is the length measured from the tip of the snout to the base of the caudal fin.
Strain	A distinct variety or breed of a plant or animal.
Stress	A term that has various definitions. The most appropriate one is related to the unfavourable environment of an organism. Accordingly, stresses are disturbing environmental forces that cause cerebral and physical strains and tensions in a living organism. Bad water quality, rough handling, low/poor quality of feed, presence of pathogens and some other factors, such as noise and vibration, are the most important stress factors for fish.
Structures	The different tanks, ponds, canals and monks that are built out of concrete or earth.
Surface loading rate	Indicates that quantity of water (Q) expressed in litres per second or cubic metres per minute or cubic metres per hour with which each square metre of a settling device can be loaded.
Surface loading rate of rectangular settling tanks	(Q/A) can be calculated with the equation of $Q = L \times W \times V_S$ or $Q = A \times V_S$, in which Q is the water flow (in litres per second, cubic metres per minute or cubic metres per hour) that should pass through the settling tank, L is the length, W is the width and A is the surface area of the settling tank, and V_S indicates the sinking speed (velocity) of particles that should be removed from the water (Pálhidy, 1997). It is important in designing a rectangular settling tank that the water should flow evenly (without turbulence) through the tank within the same period of time that is equal to the time needed for the particles to settle. This ensures that the tank will retain/settle the floating particles. For this reason, the cross-section (height multiplied by width; $H \times$ W) of the settling tank should ensure the required even and slow speed of the passing water (V_W) equal to the settling speed (V_S) of the particles aimed to be removed from the system (Illés, Kelemen and Öllős, 1983; Pálhidy, 1997).
Surface waters	Streams, rivers, canals, lakes, reservoirs and ponds are surface waters. Because they are exposed to the weather conditions, their water temperature fluctuates both daily and seasonally.
Swimming fry	See definition of **swim-up fry**.
Swim-up fry or **swimming fry** or **feeding larvae**	The term that indicates that development stage when the young fish gulp air from the atmosphere as well as starting to swim and feed externally from their environment.
Symbol ♀	International symbol for indicating the sex of female living organisms.
Symbol ♂	International symbol for indicating the sex of male living organisms.

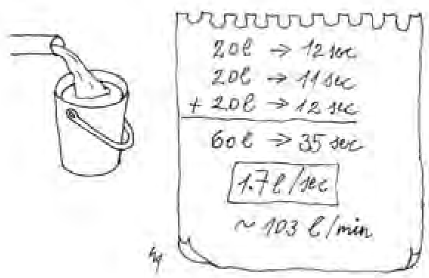
Table fish or **pan fish** (pan-size fish) or **portion fish**	The term that covers the range of sizes of fish sold for human consumption. In the case of trout, this range varies from country to country. It can be as small as 115 g or as large as 340–450 g. However, the most frequent size of table fish varies between 200 g and 300 g.
Tank culture	One of the most widely used methods for intensive production of fish. Tanks, regardless of their size and material (earth, concrete, fibreglass, etc.), are suitable for keeping fish if the quality of water is good (rich in dissolved oxygen and free of metabolic products). The water quality in the tanks can be maintained by the exchange of water and supply of air or oxygen. Tanks can be supplied by flow-through water, or the water can be partially or fully recirculated after its mechanical and biological filtration. Biologically complete feed should be fed to fish reared in tanks. The production in tanks should be expressed as the quantity of fish produced per unit volume (number of fish per cubic metre or kilograms of fish per cubic metre).
Tarpaulin	A heavy-duty waterproof cloth. Originally, it was tarred canvas, but in modern times canvas is coated with plastic materials or it is made out of waterproof artificial fibres.
Taxonomy	The theory and practice of classifying and naming living organisms.
Tempering	See definition of **acclimatization**.
Thermal shock	The shock that is caused by sudden or rapid change of water temperature.
TL	The total length of fish. This measurement also includes the caudal fin of the fish.
Transport of eyed eggs in box	Eyed eggs are transported in closed boxes on trays with ice. In this case, the eyed eggs are hibernated during the transport. The ice is placed on the uppermost tray of the transporting box. From the tray, the melting ice provides for a continuous cool temperature as well as ensuring the necessary moistening of the eyed eggs. The water melted from the ice drops through the bottom perforations of the trays and accumulates at the bottom of the box.
Trout	Globally produced trout belong to the **genera** of *Salmo*, *Oncorhynchus* and *Salvelinus* of the Salmonidae family, like Adriatic trout (*Salmo obtusirostris*), brown trout (*Salmo trutta*), flathead trout (*Salmo platycephalus*), Soča trout (*Salmo trutta marmoratus*), Ohrid trout (*Salmo letnica*), Sevan trout (*Salmo ischchan*), Aral trout *(Salmo trutta aralensis*), Amu-Darya trout (*Salmo trutta oxianus*), Apache trout (*Oncorhynchus apache*), cutthroat trout (*Oncorhynchus clarki*), gila trout (*Oncorhynchus gilae*), golden trout (*Oncorhynchus aguabonita*), rainbow trout (*Oncorhynchus mykiss*), Mexican golden trout (*Oncorhynchus chrysogaster*) and Iwame trout (*Oncorhynchus iwame*), aurora trout (*Salvelinus fontinalis timagamiensis*), brook trout (*Salvelinus fontinalis*), bull trout (*Salvelinus confluentus*), Dolly Varden trout (*Salvelinus malma*) and **lake trout** (*Salvelinus namaycush*).
Water filter	See definition of **biological water filter**.
Yolk sac	The sac attached to the developing embryo and fry of fish provides for nourishment until fry swim up, gulp air and start external feeding. By the time the young fish are fit to feed from their environment, the yolk sac has been fully used.

Annex 1

MEASUREMENT AND CALCULATION OF WATER FLOW

Frequently, the water flow from pipes or of streams, canals and raceway tanks should be measured. For accurate measurements, a stopwatch or at least a watch, with mechanical or digital second reading option, is indispensable.

FIGURE A1.1



Measurement and calculation of water flow from a pipe

When water arrives from a pipe, the easiest way to measure and calculate the quantity of passing water is to put a 10–20 litre bucket under the water flow and measure the seconds it takes for the bucket to fill up.

For the sake of accuracy, do it 2–3 times.

Then, the quantity of measured water expressed in litres should be divided by the time taken (in seconds). This will be the quantity of water that arrives in one second (litres/sec).

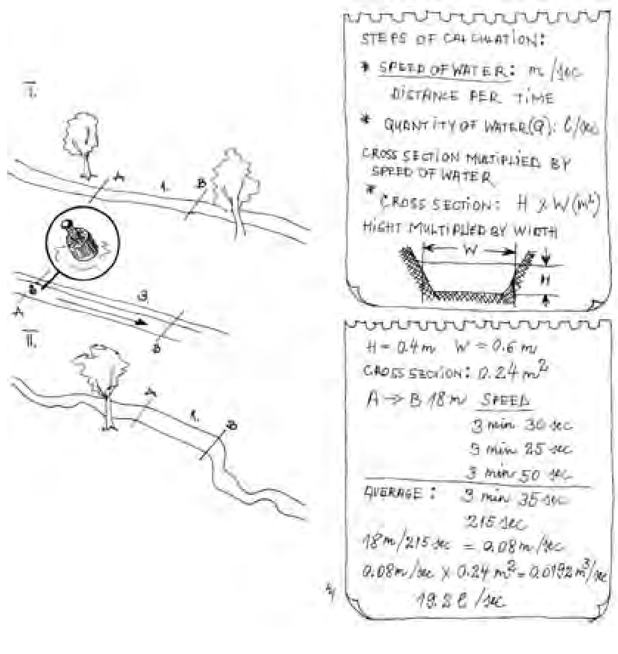
If you want to calculate the quantity of water that arrives in a minute, hour or day, you should multiply the result accordingly. See also Table A10.2.

FIGURE A1.2

Measurement and calculation of water flow in canals, raceway tanks and streams

I. Measurement and calculation of water flow in a canal or raceway tank with regular shapes is simple because the cross-sections are regular. Hence, the values can be read and calculated without estimations.

II. Measuring and calculation of water flow in a stream with irregular shapes needs the estimations of the cross-section where the banks of the stream are parallel. The values read should be arranged in an estimated shape to calculate the area.



Steps in calculations are:

1. Set the length of the section to be measured.
2. Measure the dimensions of the cross-section and calculate its area. This is the multiplication of width (W) by depth (D).
3. Measure the speed of the water with a small object that floats from point “A” to point “B”. With 2–3 repetitions, the average speed of the object can be calculated.

Multiplication of the cross-section (in square metres) by the average speed (in metres per second) of the floating object will give the quantity (volume) of water (in cubic metres) that passes within the measured time. This quantity divided by the measured time will indicate how much water passes within one second. For calculating longer periods of time, use the exchange values presented in Table A10.2.

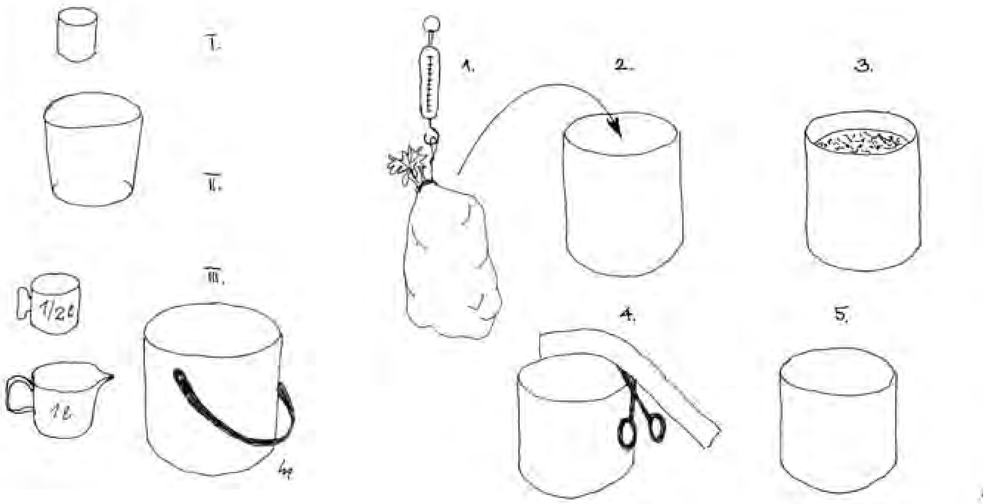
Annex 2

CALIBRATION OF FEED-MEASURING CONTAINERS

Although the use of different scales is important for weighing production materials such as feeds, the daily jobs need a quick solution. The answer is to use different measuring containers. The concept of the use of such tools is that the different feeds (or any other materials) can be quickly and accurately portioned by volume with a measuring container, which was calibrated earlier.

Some of the feed-producing companies supply measuring containers. However, fish farmers can select and calibrate their own. These containers can be buckets, bowls, cups or even tin cans.

FIGURE A2.1



Steps in the calibration of measuring containers

First, the containers should be selected according to the size of the different feeds. Plastic and aluminium kitchen measuring pots are ideal for this purpose. Select those that hold a round basic unit of the used feed; consequently, containers for: **I.** 10 g fry feed; **II.** 100 g fry feed; and larger ones for **III.** 0.5 kg, 1 kg and 5 kg of feed. If there is no such container, a new one should be calibrated.

The steps are:

1. Weigh the planned round quantity of feed.
2. Place it into the container.
3. Mark the level. For the sake of accuracy, do it 2–3 times.
4. If the calibrated new measuring container remains strong, its edge can be cut. Trim the edge of the container. This will allow quicker portioning.
5. When it is sure that the measured and marked volume is correct, the container is ready to use.

Annex 3

MEASUREMENT AND USE OF CHEMICALS AND MEDICINES

*Chemicals** and medicines should be measured very accurately. Producers of chemicals and medicines usually provide the users with calibrated measuring cups. Where such devices are not supplied, ones similar to those pictured below can be used.

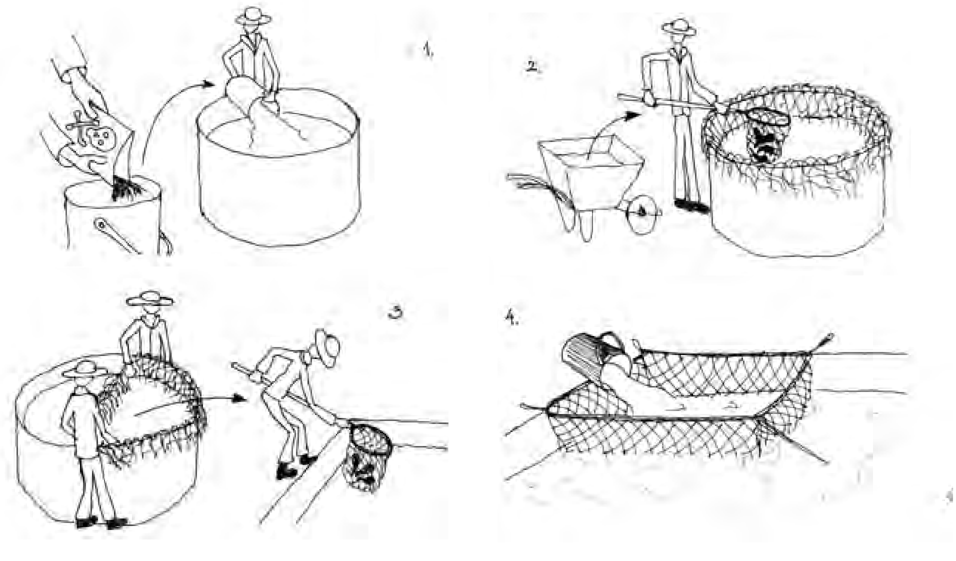
FIGURE A3.1

Measuring cups and cylinders are available in specialized shops.

For measuring very tiny volumes of liquids, use syringes of different sizes.

For weighing tiny quantities of powder or granulate, use a letter balance.

FIGURE A3.2



Dipping and bathing

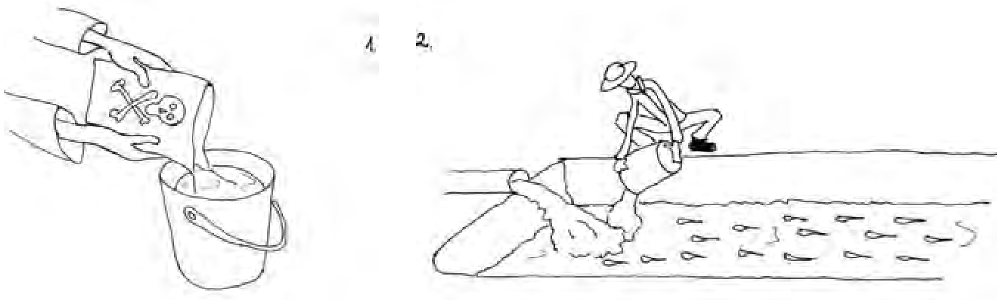
It is important to be sure that the temperature of the dipping water is equal to that of the water that fish are taken from.

The steps are:

1. Prepare a *concentrated solution** and dilute it to the exact final concentration in the bathing container.
2. Place the fish into the bathing container and leave them there as long as prescribed.
3. Remove the fish from the container into a chemical-free place where the fish can recover.
4. There are cases when fish are concentrated in a net, where the treatment is done. After treatment, the fish are released from the net. This type of treatment should be done only if the exchange of water is continuous in the tank and the final concentration of the chemical that remains in the tank is not harmful to the fish.

In fish culture, chemicals are used either for disinfection or for prevention or treatment of fish against parasites and diseases. In these cases, dangerous poisons are often used. For this reason, accurate concentrations and measurement of the duration while fish are exposed to the chemicals are the two aspects to be observed. The use of chemicals as a *remedy** in fish culture is done through bathing. Depending on the chemical applied, slow and quick bathing are distinguished. Often, they are called bathing and dipping, respectively.

FIGURE A3.3



Treatment of fish under continuous water flow

The steps are:

1. Prepare a concentrated solution.
2. Release the concentrated solution slowly and proportionally into the tank to ensure the even final concentration of the applied chemical.

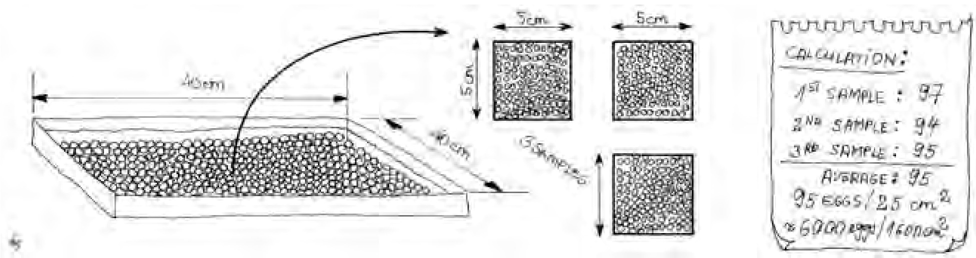
Use of medicines

Medicines are given to fish either blended in feed or through injection. In the case of feeding, medicines are mixed into the daily feed of fish in the required quantities recommended by a specialist veterinarian. In countries where the trout farming industry is advanced, the frequently needed medicines are premixed into industrial feeds. Injection of drugs or vaccination is expensive and labour-consuming but an efficient way to cure diseases. In the case of rainbow trout, injection of drugs or vaccination may be economically feasible.

Annex 4

COUNTING EYED EGGS, ADVANCED FRY AND OLDER AGE GROUPS OF FISH

FIGURE A4.1

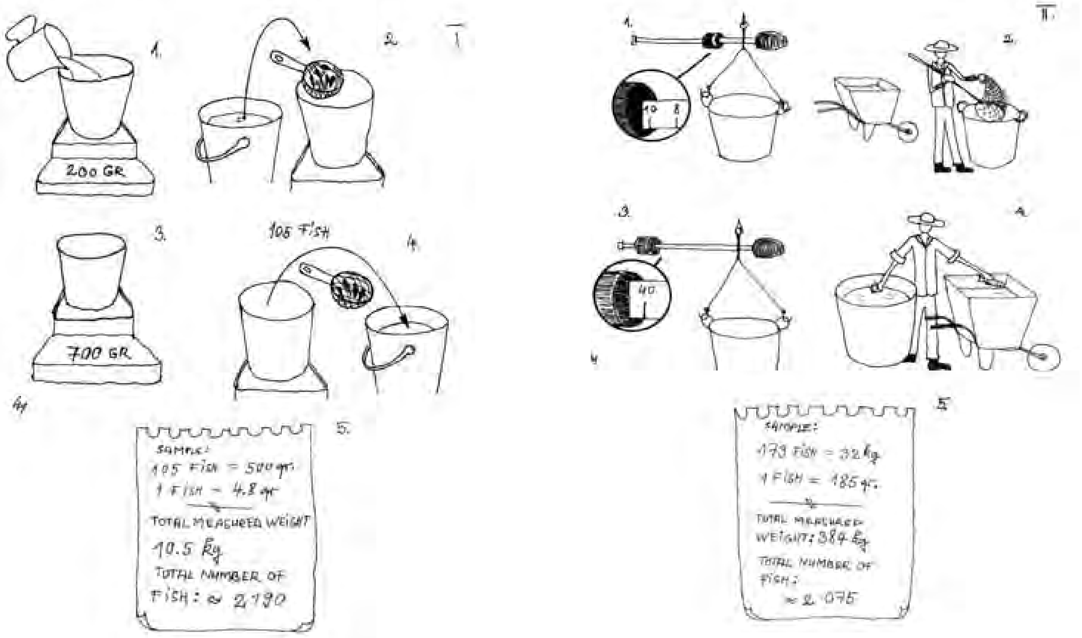


Counting eyed eggs

The steps are:

1. Count eggs on the sample frames.
2. Take the average of egg samples.
3. Calculate the total number of eggs.

FIGURE A4.2



Counting fish

The methods of counting the number of smaller (**I.**) and larger (**II.**) fish are similar. It is done by weighing 2–3 samples.

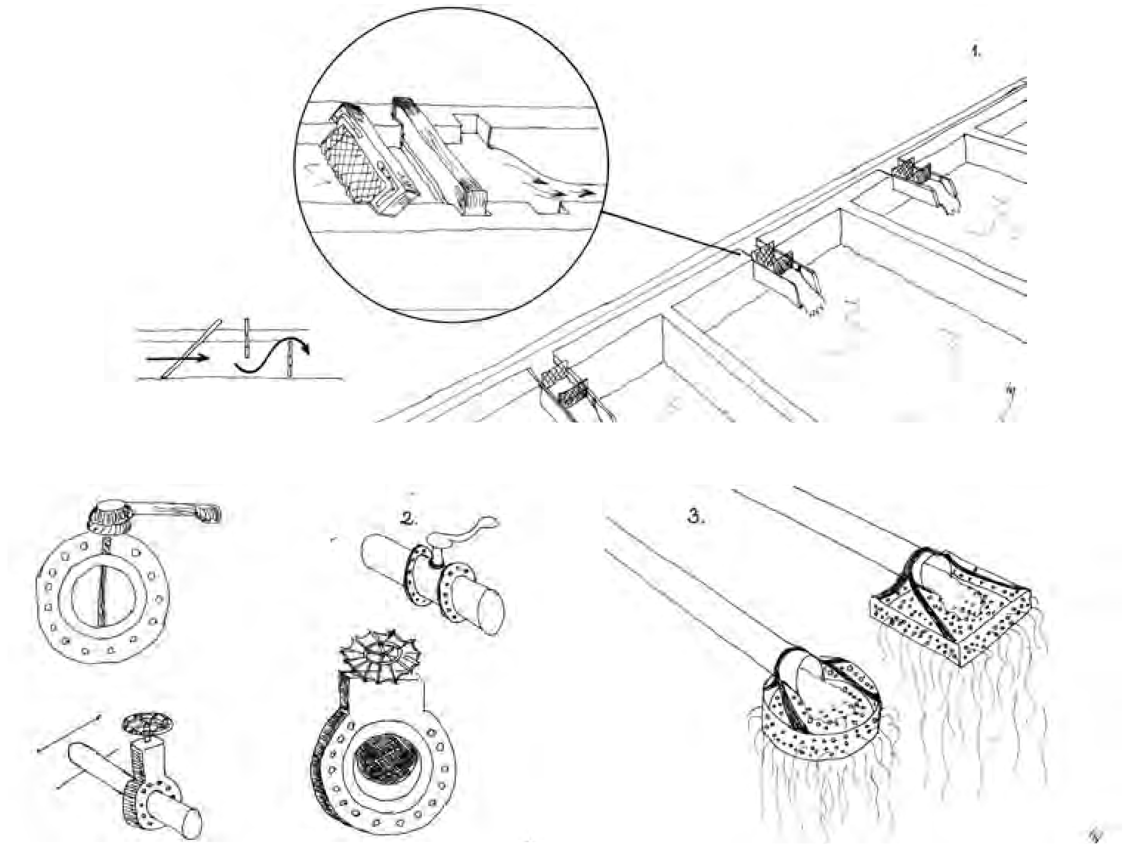
The steps are:

1. Fill 20–30 percent of a suitable container with water.
2. Fill with fish.
3. Weigh the entire container.
4. Count the fish in the samples.
5. Calculate the number of fish on the basis of the weight measured.

Annex 5

WATER SUPPLY AND DRAINAGE STRUCTURES

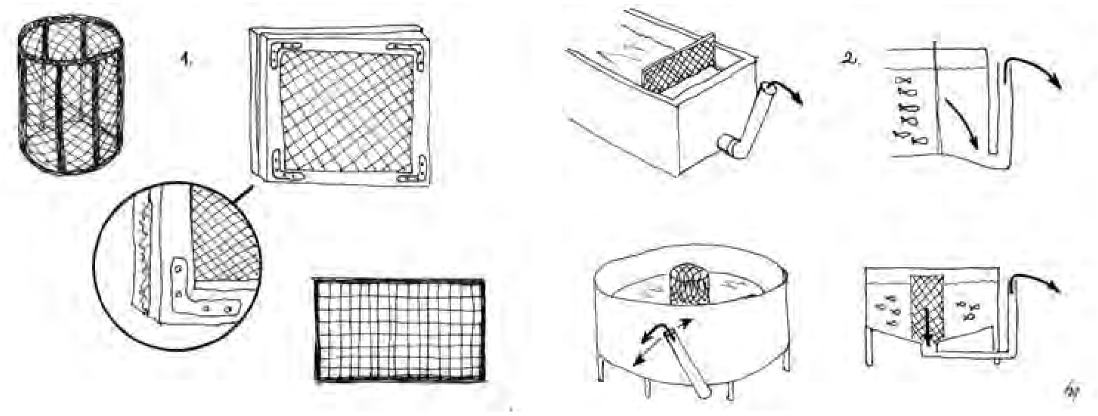
FIGURE A5.1



Water supply devices and structures

1. Water supply canals and boards. **2.** Valves and slide valves (D = 7.5–20 cm). **3.** Pipes (D = 7.5–20 cm).

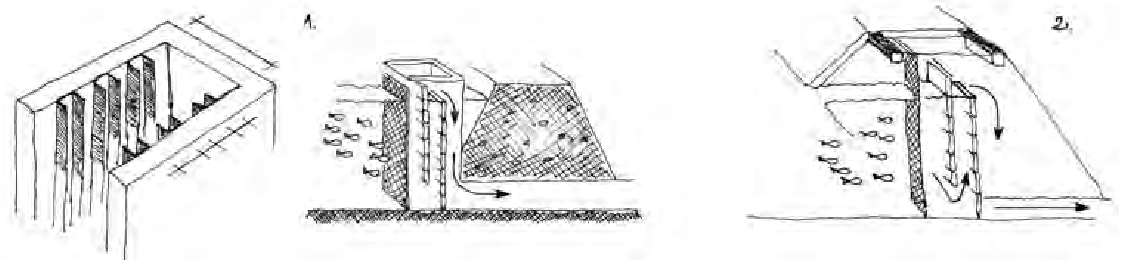
FIGURE A5.2



Water drainage devices and structures

1. Screens used to prevent escaping fish. **2.** In tanks, the turnable drainage pipes ensure that water is kept at the required level.

FIGURE A5.3



Monks with screens

1. Traditional monk. **2.** Open monk. In both cases, the parallel arrangement of the planks ensures that water is kept at the required level.

Annex 6

MECHANICAL AND BIOLOGICAL FILTERS

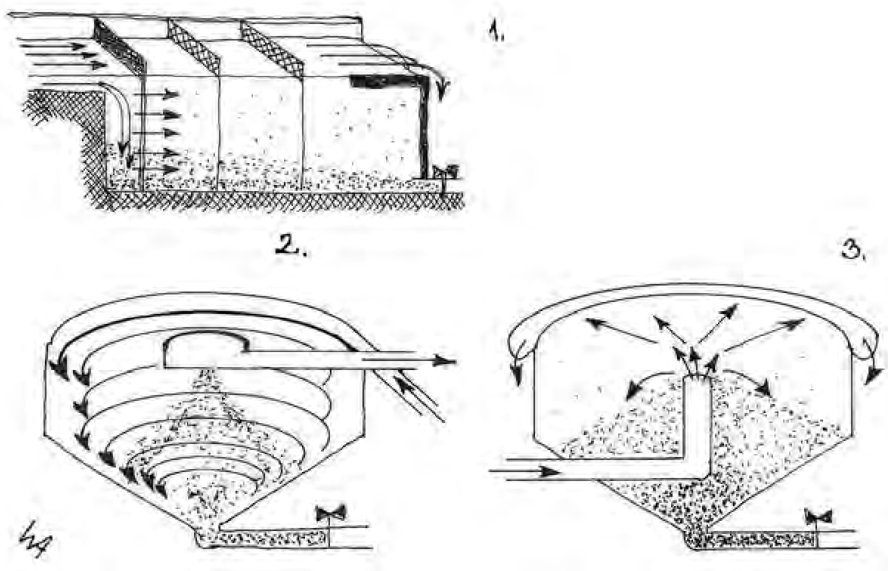
Mechanical filters

The simplest mechanical filters are the different screens that prevent floating particles from passing through them. The problem with such screens is that they soon become clogged. Therefore, they are rarely used unless the filter is continuously backwashed. Another way of removing floating particles is by settling them in special tanks.

In rectangular settling tanks, the speed of the water should slow to less than 3 cm/sec, because at this speed floating particles in the effluent of trout rearing tanks start to settle (Hoitsy, 2002). At this speed, the *surface loading rate** is about 30 litres/sec per square metre (1.8 m^3/sec per square metre), while at 2 cm/sec and 1 cm/sec, the surface loading rates will be 20 litres/sec per square metre (1.2 m^3/sec per square metre) and 10 litres/sec per square metre (0.6 m^3/sec per square metre), respectively. These values in a rectangular settling tank can already ensure the settlement of most of the floating particles. When screens, lamellas or tubes are placed in a rectangular settling tank, its efficiency increases.

Open hydrocyclones (also called swirl separator) and radial-flow settler are devices that remove floating particles in a different way from the way rectangular settling tanks do. They are more efficient gravity settling vessels than the rectangular settling tanks (Piggott, 2007). This greater efficiency can be as much as fourfold.

FIGURE A6.1



Settling tanks

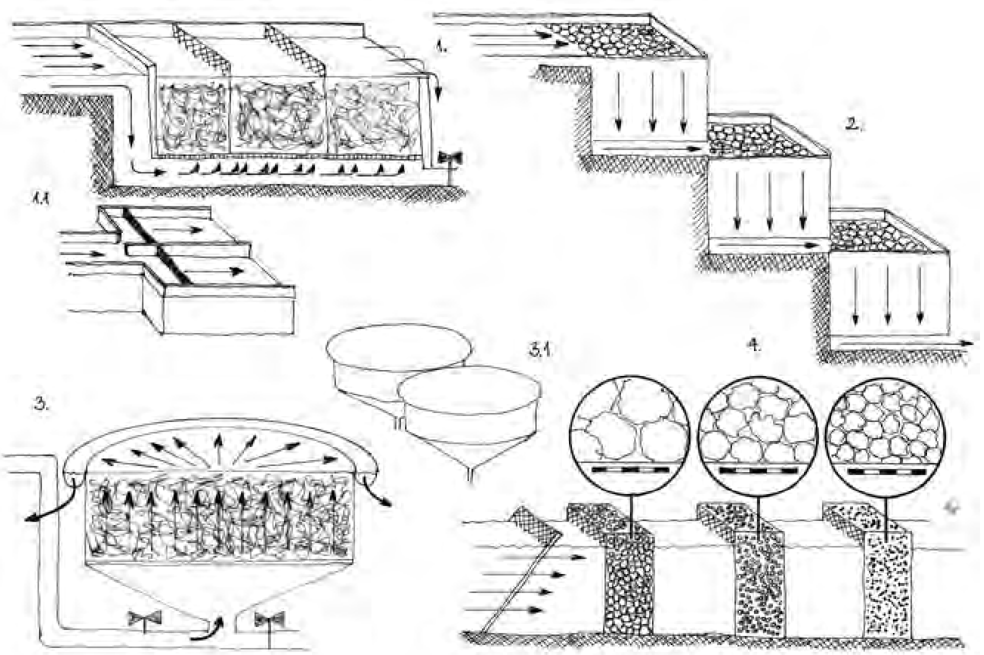
1. Rectangular settling tank. **2.** Open hydrocyclone or swirl separator. **3**. Radial-flow settler.

Biological filters

In order to ensure the development of efficient quantities of bacteria, a biofilter should have a large surface. The material of the media where bacteria can develop in a biofilter may be different. Gravel, pebbles, chips of stone, different plastics, shell of molluscs, etc., are all suitable for this purpose. Their suitability is compared on the basis of the total surfaces of one cubic metre volume (in terms of square metres per cubic metre). Biofilters can be submerged or of the trickling type, serving slightly different purposes. Water coming into contact with the submersible filters must be saturated with oxygen. In the case of a trickling filter, this is done automatically. The size of the biofilter should be proportional to the fish production, more precisely to the quantity of feed applied. The actual size of the biofilter is determined by the surface on which bacteria can develop. Accordingly, 1 kg of feed requires a biofilter surface of about 200 m^2.

Although practically anything that has a large surface may serve as media for biofilters, materials that cannot resist the bacteria or that are difficult to handle, move or clean should not be selected.

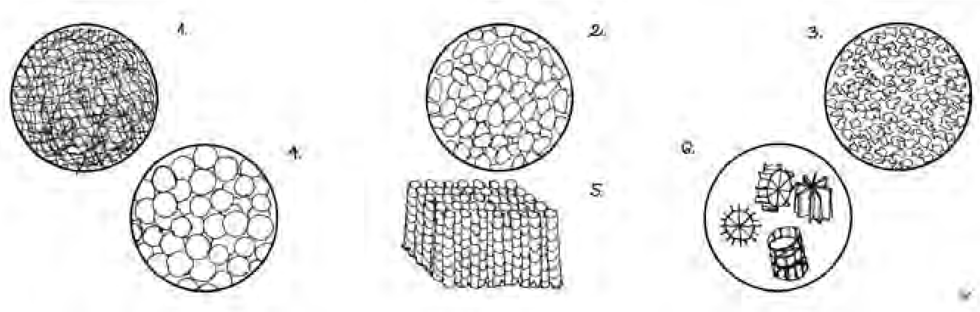
FIGURE A6.2



Biological filters

1. Biological filter placed in a tank. **1.1** Twin-arrangement facilitates cleaning. **2**. Trickling filter placed on slope. **3.** Cyclone-type biological filter. **3.1** Twin-arrangement facilitates cleaning. **4.** Stone chips are used as both mechanical and biological filters, although their cleaning is difficult.

FIGURE A6.3



Media of biological filters

Materials of biological filters for developing bacteria **1.** Netting material (~ 50–100 m^2/1 m^3). **2.** Stone chips or pebbles (~ 150 m^2/1 m^3). **3.** Plastic chips (~ 150–450 m^2/1 m^3). **4.** Polyphone balls “bead” (diameter 1.5 mm: 8 000 m^2/1 m^3). **5.** Lamella (250–350 m^2/1 m^3). **6.** Loose biomedia (~ 800 m^2/1 m^3).

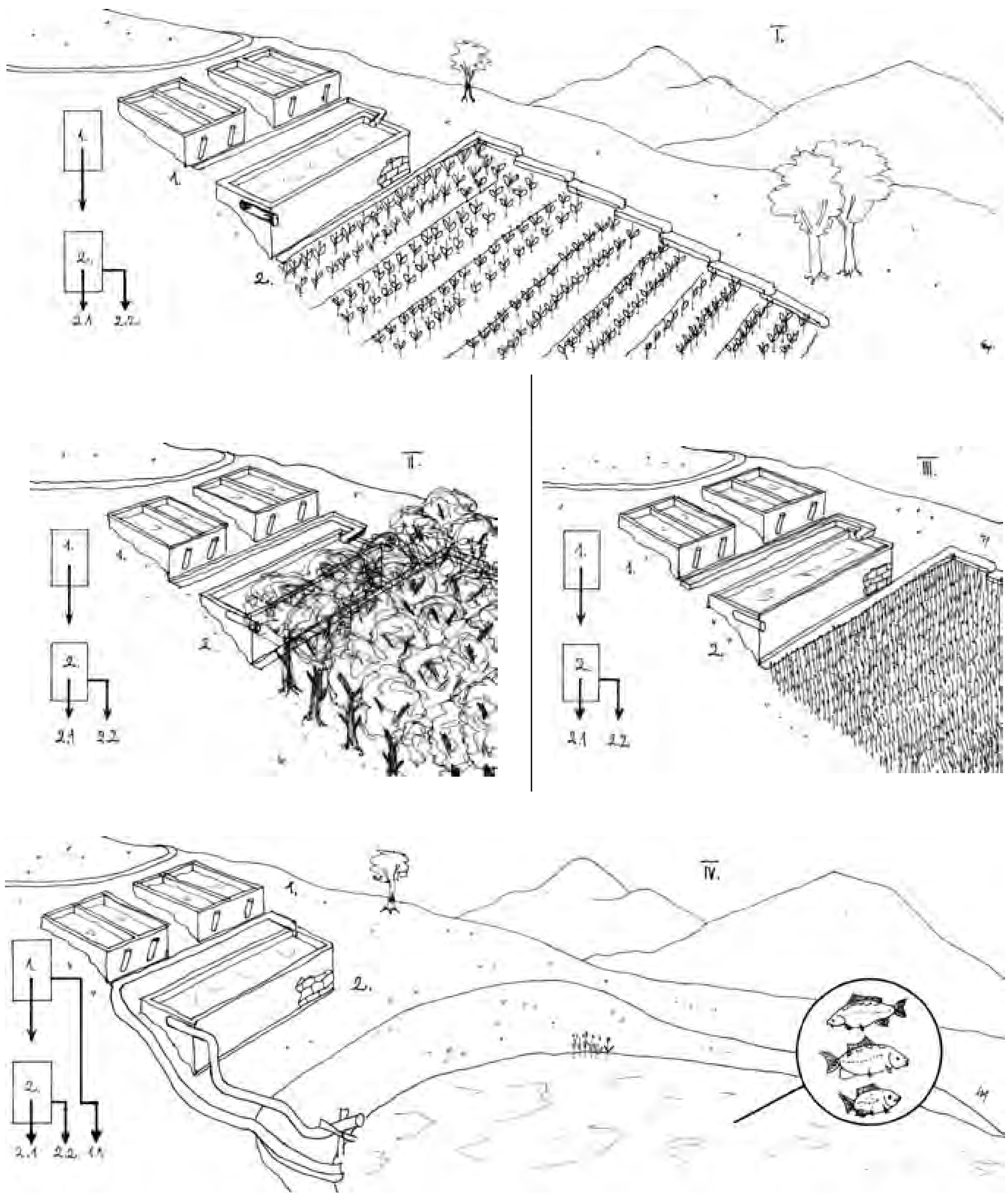
Open-air filter systems

Effluents of trout farms can be utilized for irrigation, wetlands or carp pond polyculture. Construction and use of a mechanical filter is recommended in all cases. After mechanical filtration, water and sludge can be used separately.

In the case of carp pond polyculture, effluents produced from spring to autumn can be used without mechanical filtration. The effluents of the production of 10 tonnes of trout can be utilized and absorbed by a pond of about 500 m^2 for common carp or/and bream. During the cold season, the appetite of these species reduces, at which time the effluent should be filtered and used as manure.

About 1 litre/sec of outflowing water is enough to irrigate 1 ha of land, while, according to specialists, the effluents of the production of 10 tonnes of fish can be treated and absorbed by 1 000–2 000 m^2 of wetland.

FIGURE A6.4



Types of large, open-air filter systems

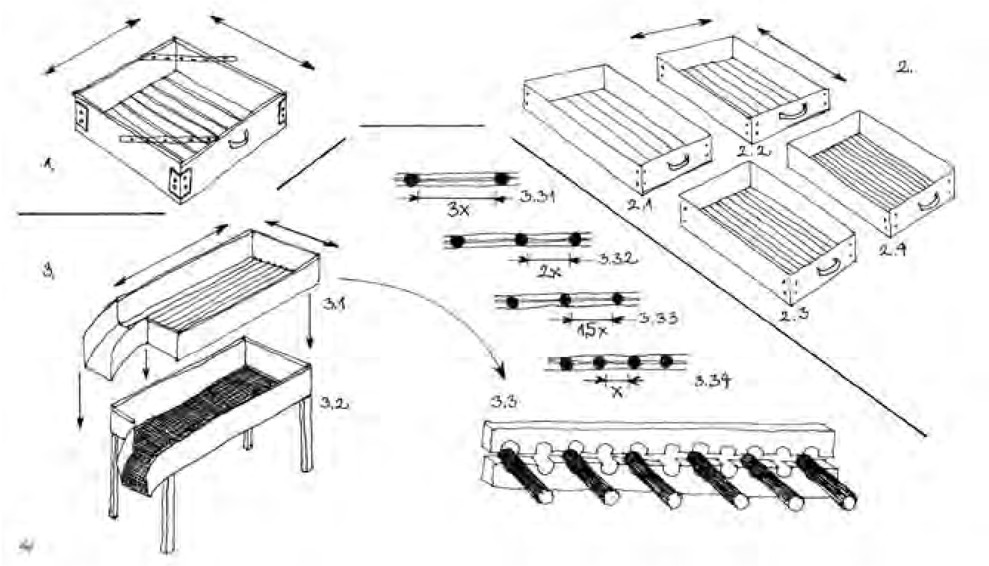
I. Irrigated land. **II.** Irrigated plantation of trees. **III.** Reed bed. **IV.** Fish pond.

Steps in filtering effluent: **1.** Trout production unit. **2.** Mechanical filter (**2.1** water; and **2.2** sludge).

Annex 7

EQUIPMENT, NETS AND HAND TOOLS

FIGURE A7.1



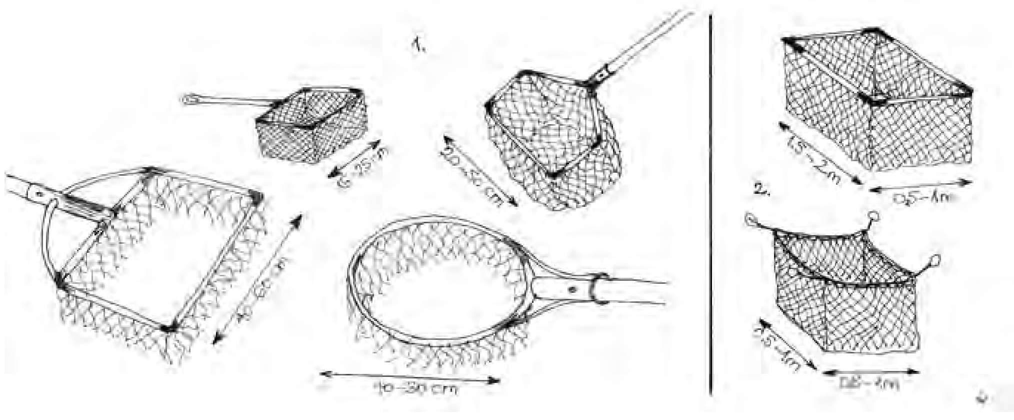
Equipment of fish grading

1. Adjustable hand grader. **2.** Set of hand graders. **3.** Sorting table with changeable bars (after Hoitsy).

Steps in hand grading: First the smallest, then through to the largest size is fixed on the grader.

Steps in grading on table: Place small quantities of fish on the grading bars, through which the smaller fish fall and slip into the collecting container, while the larger ones will slip into the other container.

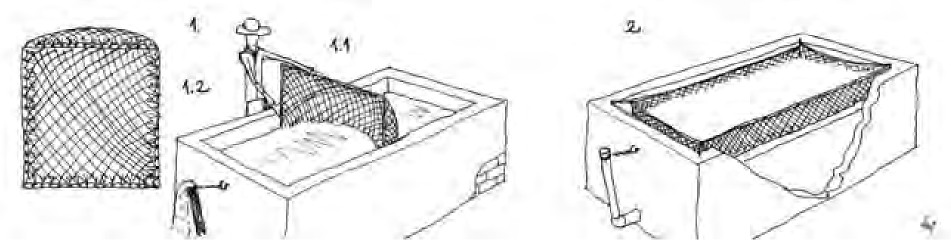
FIGURE A7.2



Hand and holding nets

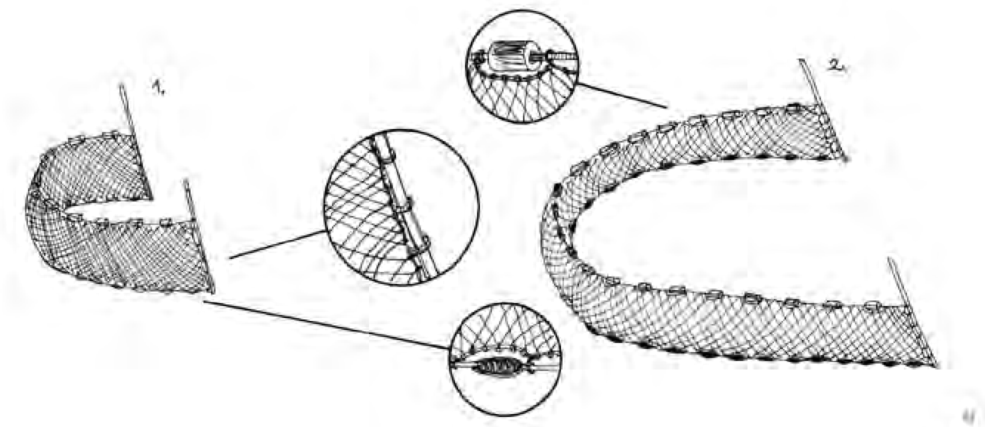
1. Hand nets of different sizes. **2.** Holding nets of different sizes.

FIGURE A7.3



1. Net mounted on a frame will facilitate its use. **2.** Holding net fixed in a concrete tank can help easy and quick removal of fish (after Woynarovich and Woynarovich [1998]).

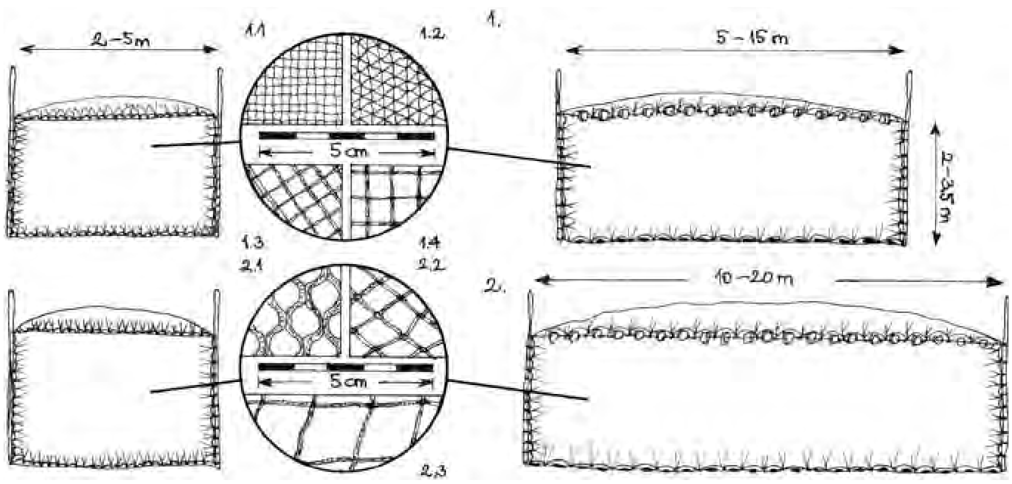
FIGURE A7.4



Seines

Seines mounted with floats and weights are used in tanks and ponds. These nets should be deep and wide enough. **1.** Smaller net for concrete tank. **2.** Drag net for earth pond. It is a general rule that such nets should be at least 50 percent times wider and deeper than the depth and the width of the tank or pond in which they are used.

FIGURE A7.5



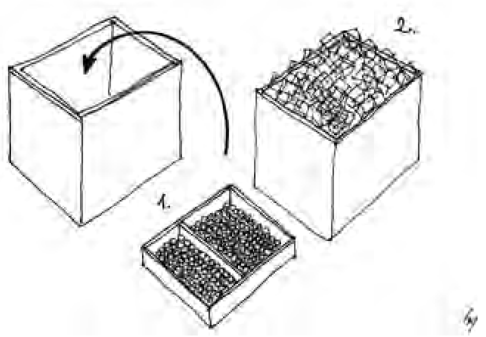
Mesh size of nets

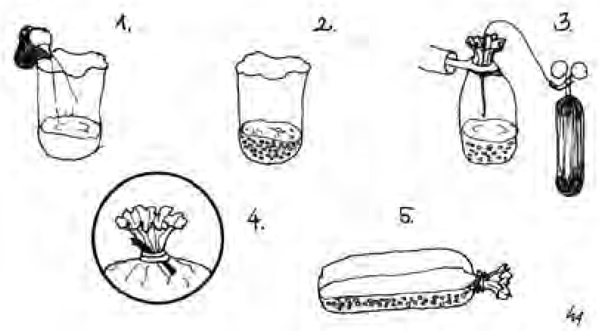
Fish of any size should be captured with the suitable mesh size of the net (after Woynarovich and Woynarovich [1998]).

Annex 8

TRANSPORT OF EYED EGGS AND DIFFERENT AGE GROUPS OF RAINBOW TROUT

FIGURE A8.1





Transport of eyed eggs in box

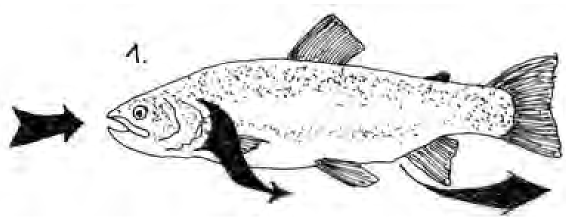
The steps are: **1.** Place eggs onto the trays of the carrying box. **2.** Place ice on the top tray.

Transport of eyed eggs in plastic bag

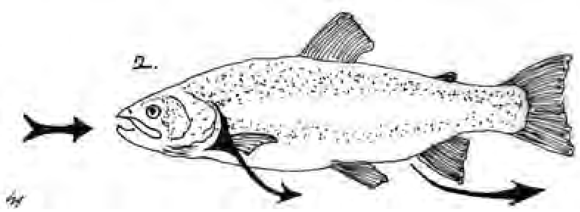
The steps are: **1.** Fill one-third of the bag with water. **2.** Place the eggs in the bag. **3.** Fill up the bag with oxygen. **4.** Close the bag with rubber band. **5.** Place in position for transport.

Preparation of fish for transport is important because fish, full of feed, consume more oxygen and release more harmful gases and faeces, and they are more stress sensitive. During preparation of fish for transport, the fish should be kept without feeding in running water in order to empty their digestive tracts.

FIGURE A8.2



Intensity of the metabolism of trout is intense before (**1.**) and reduces after (**2.**) the preparation of fish for transport.



Recommended length of the preparation of trout for transport

Temperature (°C)	Duration (hours)
12–18	12–18
9–10	24–26
5–6	36–40
2–3	72–80

Source: Hoitsy.

FIGURE A8.3

Transport of fish in plastic bag

A less equipment-demanding way of transporting fish is to use a 30 or 60 litre plastic bag in which the proportion of water and pure oxygen is 1:2 (one-third water and two-thirds oxygen). Accordingly, in such a bag, there will be about 10–20 litres of water.

The numbers of fish transported in 20 litres of water in a bag depends on the size of fish, the temperature of the transporting water and the duration of transport. Some reference figures for a few hours of transport are shown in the graphs (water temperature: 5–10 °C).

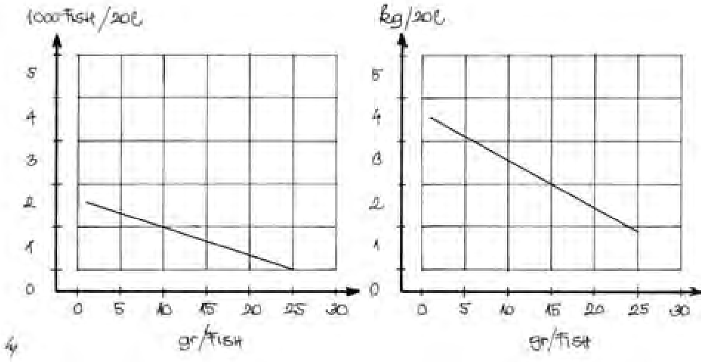
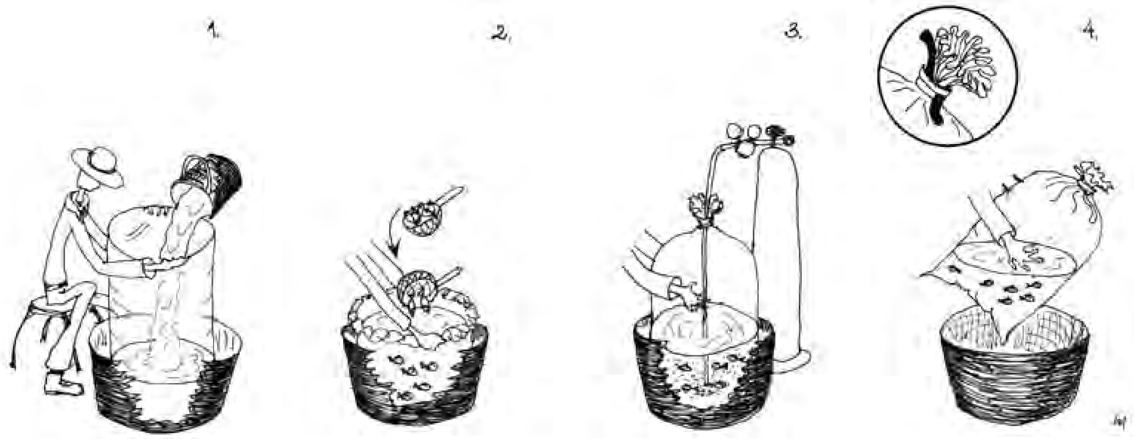


FIGURE A8.4



Packing fish into plastic bag

The steps are: **1.** Fill the bag with water. **2.** Place the fish into the bag. **3.** Fill the bag with oxygen. **4.** Close the bag with rubber band, made out of used tyre (Woynarovich and Woynarovich [1998]).

FIGURE A8.5

Transport of fish in tank

The transport of fish in a container with continuous oxygen supply is the usual way of moving large quantities of live trout.

The size of the container may vary from a few hundred litres up to few cubic metres. The usual size of transporting container for a smaller vehicle is about 500 or 1 000 litres.

The quantity of fish that can be transported per cubic metre of water at 5–10 °C with continuous diffusion of oxygen for about 4–8 hours is shown in the graphs (after Berka [1986]).

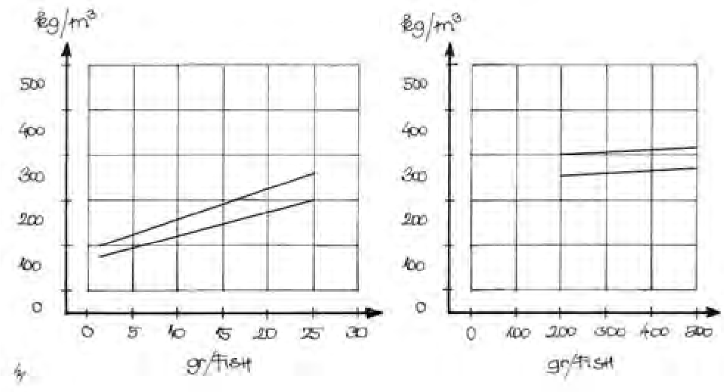


FIGURE A8.6

Preparation and loading of trout for transport

The steps are: **1.** Fill the container half full with water. **2.** Place and test the oxygen diffuser. **3.** Place the fish into the container. **4.** Fill up the container with water and close it (Woynarovich and Woynarovich [1998]).

Annex 9

FREQUENT DISEASES OF RAINBOW TROUT

There are a range of different diseases of rainbow trout that are caused by viruses, bacteria, fungi and parasites, but the environment- and nutrition-related diseases are also rather frequent if the production conditions deteriorate. For the diseases listed below, where measurements cannot be given,[1] consultation with a veterinarian specialized in this field is not only suggested but explicitly recommended.

Frequent **diseases caused by virus** are:

- **Viral haemorrhagic septicaemia (VHS)**, which is a very serious viral disease of farmed rainbow trout.
  Symptoms: Darkened skin, swim erratically, absence of feed in the gut, fluid in the abdomen, *exophthalmia**, internal *haemorrhages** (liver, muscle), swollen kidney, pale or yellow-grey liver.
  Causes: Rhabdovirus.

- **Infectious pancreatic necrosis (IPN)**, which causes high mortalities in young salmonid fishes.
  Symptoms: Behavioural changes (swim unsteadily, *ataxia**) and gross external and internal lesions, as well as anorexia. Other external signs are hyperpigmentation, exophthalmia, haemorrhagic patches on the ventral surfaces. Other internal signs are visceral *petechia**, empty gut with yellow exudates, as well as necrosis of the pancreas and of the kidney.
  Causes: Birnavirus.

- **Infectious haematopoietic necrosis (IHN)** – In acute disease, there is a sudden increase in fish mortality, but the fish may not show clinical signs.
  Symptoms: Changing behaviour with lethargic and hyperactive phases, dark coloration, distended abdomen, exophthalmia, pale gills, liver and kidney, petechial haemorrhages of the fins, gills, mouth, skin and muscle. The stomach is filled with milky fluid.
  Causes: Rhabdovirus.

Frequent **diseases caused by bacterium** are:

- **Furunculousis**
  Symptoms: Exophtalmus, hemorrhagic patches along the side or on the dorsal body surfaces, bloody anal vents and furuncles on the body surface.
  Causes: *Aeromonas salmonicida.*

- **Enteric Red-mouth Disease (ERM)**
  Symptoms: Reddening of the throat and mouth, erosion of the jaw, haemorrhage on the body surface, at the gill tips, at the base of the fins, congestion of the blood vessels, petechial haemorrhages on the liver, pancreas, swim-bladder. The kidney and the spleen are swollen.
  Causes: *Yersinia ruckeri.*

[1] The applicable rules and regulations and the permitted chemicals and medicines in fish farming may differ from country to country in the countries of CEE and CCA. Therefore, the applicable measurements for many common fish diseases may be different.

- **Columnaris disease**
  Symptoms: It starts with greyish-white spots on the body of the fish, often on the head, lips or fin. The initial lesions are small and circular with greyish-blue centres and red margins surrounded by a ring of inflamed skin.
  Causes: *Flavobacterium columnare.*

- **Flavobacterium septicaemia (cold water disease)**
  Symptoms: Exophthalmia, abdominal swelling, reddening of the vent, enlarged spleen, hemorrhagic necrosis in muscle and viscera. In acute cases, haemorrhages may be seen in the heart, liver, swim-bladder.
  Causes: *Flavobacterium psychrophilum.*

A frequent **disease caused by fungi** is:

- **Saprolegnia** – The fungi responsible for saprolegniasis are secondary pathogens, which appear and develop after handling or after any traumatic damage to the skin of the fish.
  Symptoms: Grey-white patches on the skin, which under the water have a cotton-wool-like appearance.
  Causes: *Saprolegnia* spp.

Diseases can be caused by parasites such as:
Protozoa (e.g. *Ichthyobodo necator*, *Ichthyophthyrius multifiliis*, *Trichodina* sp., *Chilodonella* sp.) – Protozoa are single-celled eukaryotic organisms that range from being microscopic to being just visible with the eye. Most of them have a direct life cycle with no intermediate host involved. Others have indirect life cycles that involve several aquatic organisms. Protozoan infections occur in intensive culture systems.

A frequent **disease caused by parasites** is:

- **Whirling disease**
  Symptoms: The parasite destroys the cartilage in the head and in the vertebral column. The first signs are dark pigmentation; because of lesions in the cartilage, which exert pressure on the nerves, after about two months the abnormal tail-chasing behaviour (whirling) becomes noticeable. There are also deformations of the head and the spine.
  Causes: *Myxobolus cerebralis* (its alternate host, the free-living nematode *Tubifex tubifex*).

Frequent **environment-related diseases** are:

- **Acute and permanent oxygen shortage**
  Symptoms: When oxygen levels fall quickly to critically low levels, the fish can rapidly develop respiratory stress and may die. The respiratory problems manifest in increased gill beat and, in severe cases, the fish may gulp for air on the water surface. Chronic hypoxia is not necessarily lethal to the fish, but may cause stunted growth, reduced feeding and increased susceptibility to infections.
  Causes: The fish stock is not supplied with enough oxygen.
  Measures: The actual oxygen content of the water in the rearing tank should be checked not only at the inlet but also at the outlet (Bregnballe, 2010). This can be done with an oxygen kit or with an oxygen meter. Increase the water flow or/and the oxygen content of the water with aeration. Where these measures cannot be taken, the density of fish in the rearing device should be reduced.

- **Gas bubble disease** – Under certain conditions, water may become supersaturated with one or more gases, most frequently with nitrogen. In this situation, fish can develop gas emboli.
  Symptoms: Bubbles of gas appear in the edges of the body fins, in blood vessels, in all chambers of the eye, skin and gills.
  Causes: This disease is often associated with the supersaturation of the water with nitrogen or oxygen. This may occur in the wild, near to electrical water plants, or in fish farms, where powerful air or oxygen injection systems are used or where water from deep boreholes is used.

- **Poisoning –** It can be an environmental disease caused by natural events (rapid change in water quality) or caused by human activities (intensive use of agricultural chemicals, urbanization, industrialization, etc.). The water quality parameters applicable for fish farming are set by all countries. In European Union countries, the "Freshwater Fish" Directive (EEC 1978) is the applicable one.
  Symptoms: These vary, being poison-specific, but all of them cause mass mortality.
  Causes: Among others, nitrogenous wastes (ammonia, nitrite, nitrate), extreme pH, pesticides, heavy metals.
  Measures: Exchange of freshwater.

- **Stress** is related to the unfavourable environment and handling of fish. Stresses can be reduced easily with observation and application of the correct fish production technology.

Frequent **nutrition-related diseases** are:

- **Fusariosis**
  Symptoms: Focal (localized) hepatic necrosis, oedema, generalized haemorrhagic syndrome, infection of digestive track and hepatic *carcinoma**.
  Causes: Mycotoxins.
  Measures: Changing of feeds.

- **Vitamin and mineral deficiency –** Vitamins are complex organic substances that are essential to a wide variety of metabolic processes. Approximately 15 different vitamins are known to be important for fish. Fish also require minerals for different metabolic processes, such as haemoglobin synthesis, as well as for enzyme/hormone functions.
  Symptoms: These vary, but normally cause reduced growth or deformation. Measurements: Changing of feeds.

- **Fatty feed**
  Symptoms: Damage and deformation of liver and bile.
  Causes: There is too much fat in the feed of the fish.
  Measures: Reduction of the fat content of the feed.

Annex 10

TABLES

TABLE A10.1
Measurements

SI* unit	Multiples and submultiples		Symbol	Observation
	Name	Value		
Weight (mass)				
	tonne	1 000	t or mt	
kilogram		***1***	***kg***	
	dekagram	*0.01*	*dkg*	*Not official SI submultiple*
	gram	0.001	g	
	milligram	0.000001	mg	
	microgram	0.000000001	µg	
Length				
	kilometre	1 000	km	
	decametre	*10*	*dam or dkm*	*Not official SI multiple*
metre		***1***	***m***	
	decimetre	*0.1*	*dm*	*Not official SI submultiple*
	centimetre	0.01	cm	
	millimetre	0.001	mm	
	micrometre	0.000001	µm	
Area				
	square kilometre	1 000 000	km^2 or sq km	
	hectare	10 000	ha	Approved and used unit
	are	100	a or are	Approved and used unit
square metre		***1***	***m^2***	***1 m × 1 m***
	square decimetre	0.01	dm^2 or sq dm	
	square centimetre	0.0001	cm^2 or sq cm	
	square millimetre	0.000001	mm^2 or sq mm	
Volume				
cubic metre		***1***	***m^3***	***1 m × 1 m × 1 m***
	cubic decimetre	0.001	dm^3 or cu dm	10 cm × 10 cm × 10 cm
	or litre		l or litre	
	cubic centimetre	0.000001	cm^3 or cu cm	
	or millilitre		ml	
	cubic millimetre	0.000000001	mm^3 or cu mm	
Capacity				
	cubic metre	1 000	m^3	
litre		***1***	***l or litre***	***10 cm × 10 cm × 10 cm***
	millilitre	0.001	ml	
	microlitre	0.000001	µl	
Speed				
	kilometre/hour		km/h	
	metre/minute		m/min	
metre/second			***m/s or m/sec***	
	millimetre/second		mm/s or mm/sec	
Time				
	day	86 400	day or d	24 × 60 × 60
	hour	3 600	hour or h	60 × 60
	minute	60	min	1 × 60
second		***1***	***sec***	
Speed of water flow				
	litres/day		litres/day	
	litres/hour		litres/hour	
	litres/minute		litres/min	
	litres/second		litres/sec	

TABLE A10.2
Water flow

litres/second	litres/minute	litres/hour	litres/day
0.02	1	60	1 440
0.03	2	120	2 880
0.05	3	180	4 320
0.07	4	240	5 760
0.08	5	300	7 200
0.10	6	360	8 640
0.12	7	420	10 080
0.13	8	480	11 520
0.15	9	540	12 960
0.17	10	600	14 400
0.18	11	660	15 840
0.20	12	720	17 280
0.22	13	780	18 720
0.23	14	840	20 160
0.25	15	900	21 600
0.27	16	960	23 040
0.28	17	1 020	24 480
0.30	18	1 080	25 920
0.32	19	1 140	27 360
0.33	20	1 200	28 800
0.35	21	1 260	30 240
0.37	22	1 320	31 680
0.38	23	1 380	33 120
0.40	24	1 440	34 560
0.42	25	1 500	36 000
0.43	26	1 560	37 440
0.45	27	1 620	38 880
0.47	28	1 680	40 320
0.48	29	1 740	41 760
0.50	30	1 800	43 200
0.52	31	1 860	44 640
0.53	32	1 920	46 080
0.55	33	1 980	47 520
0.57	34	2 040	48 960
0.58	35	2 100	50 400
0.60	36	2 160	51 840
0.62	37	2 220	53 280
0.63	38	2 280	54 720
0.65	39	2 340	56 160
0.67	40	2 400	57 600
0.68	41	2 460	59 040
0.70	42	2 520	60 480
0.72	43	2 580	61 920
0.73	44	2 640	63 360
0.75	45	2 700	64 800
0.77	46	2 760	66 240
0.78	47	2 820	67 680
0.80	48	2 880	69 120
0.82	49	2 940	70 560
0.83	50	3 000	72 000
0.85	51	3 060	73 440
0.87	52	3 120	74 880
0.88	53	3 180	76 320
0.90	54	3 240	77 760
0.92	55	3 300	79 200
0.93	56	3 360	80 640
0.95	57	3 420	82 080
0.97	58	3 480	83 520
0.98	59	3 540	84 960
1.00	60	3 600	86 400
1.02	61	3 660	87 840
1.03	62	3 720	89 280
1.05	63	3 780	90 720
1.07	64	3 840	92 160
1.08	65	3 900	93 600
1.10	66	3 960	95 040
1.12	67	4 020	96 480
1.13	68	4 080	97 920
1.15	69	4 140	99 360
1.17	70	4 200	100 800
1.18	71	4 260	102 240
1.20	72	4 320	103 680
1.22	73	4 380	105 120
1.23	74	4 440	106 560
1.25	75	4 500	108 000
1.27	76	4 560	109 440
1.28	77	4 620	110 880
1.30	78	4 680	112 320
1.32	79	4 740	113 760
1.33	80	4 800	115 200
1.35	81	4 860	116 640
1.37	82	4 920	118 080
1.38	83	4 980	119 520
1.40	84	5 040	120 960
1.42	85	5 100	122 400
1.43	86	5 160	123 840
1.45	87	5 220	125 280
1.47	88	5 280	126 720
1.48	89	5 340	128 160
1.50	90	5 400	129 600
1.52	91	5 460	131 040
1.53	92	5 520	132 480
1.55	93	5 580	133 920
1.57	94	5 640	135 360
1.58	95	5 700	136 800
1.60	96	5 760	138 240
1.62	97	5 820	139 680
1.63	98	5 880	141 120
1.65	99	5 940	142 560
1.67	100	6 000	144 000
3.33	200	12 000	288 000
5.00	300	18 000	432 000
6.67	400	24 000	576 000
8.33	500	30 000	720 000
10.00	600	36 000	864 000
11.67	700	42 000	1 008 000
13.33	800	48 000	1 152 000
15.00	900	54 000	1 296 000
16.67	1 000	60 000	1 440 000

TABLE A10.3

Correlation between the quantity of water and daily and hourly exchange rates

Daily exchange rate	Hourly exchange rate	litres/min to supply 1 m^3 tank	litres/sec to supply 1 m^3 tank
1	0.0	0.7	0.01
2	0.1	1.4	0.02
3	0.1	2.1	0.03
4	0.2	2.8	0.05
5	0.2	3.5	0.06
6	0.3	4.2	0.07
7	0.3	4.9	0.08
8	0.3	5.6	0.09
9	0.4	6.3	0.10
10	0.4	6.9	0.12
11	0.5	7.6	0.13
12	0.5	8.3	0.14
13	0.5	9.0	0.15
14	0.6	9.7	0.16
15	0.6	10.4	0.17
16	0.7	11.1	0.19
17	0.7	11.8	0.20
18	0.8	12.5	0.21
19	0.8	13.2	0.22
20	0.8	13.9	0.23
21	0.9	14.6	0.24
22	0.9	15.3	0.25
23	0.96	16.0	0.27
24	1.00	16.7	0.28
25	1.0	17.4	0.29
26	1.1	18.1	0.30
27	1.1	18.8	0.31
28	1.2	19.4	0.32
29	1.2	20.1	0.34
30	1.3	20.8	0.35
31	1.3	21.5	0.36
32	1.3	22.2	0.37
33	1.4	22.9	0.38
34	1.4	23.6	0.39
35	1.5	24.3	0.41
36	1.5	25.0	0.42
37	1.5	25.7	0.43
38	1.6	26.4	0.44
39	1.6	27.1	0.45
40	1.7	27.8	0.46
41	1.7	28.5	0.47
42	1.8	29.2	0.49
43	1.8	29.9	0.50
44	1.8	30.6	0.51
45	1.9	31.3	0.52
46	1.9	31.9	0.53
47	2.0	32.6	0.54
48	2.0	33.3	0.56
49	2.0	34.0	0.57
50	2.1	34.7	0.58
51	2.1	35.4	0.59
52	2.2	36.1	0.60
53	2.2	36.8	0.61
54	2.3	37.5	0.63
55	2.3	38.2	0.64
56	2.3	38.9	0.65
57	2.4	39.6	0.66
58	2.4	40.3	0.67
59	2.5	41.0	0.68
60	2.5	41.7	0.69
61	2.5	42.4	0.71
62	2.6	43.1	0.72
63	2.6	43.8	0.73
64	2.7	44.4	0.74
65	2.71	45.1	0.75
66	2.75	45.8	0.76
67	2.8	46.5	0.78
68	2.8	47.2	0.79
69	2.9	47.9	0.80
70	2.9	48.6	0.81
71	3.0	49.3	0.82
72	3.0	50.0	0.83
73	3.0	50.7	0.84
74	3.1	51.4	0.86
75	3.1	52.1	0.87

TABLE A10.4
Correlation between individual weight, length and number of rainbow trout in one kilogram*

Total length of fish (cm)	Rounded weight of fish (g/fish)			Rounded number of fish in 1 kg		
	Minimum	Average	Maximum	Minimum	Average	Maximum
1	–	0.1	–	–	10 000	–
2	–	0.2	–	–	5 000	–
3	0.2	0.4	0.5	5 600	2 600	2 000
4	0.6	0.7	0.8	1 600	1 500	1 300
5	1.0	1.5	2.0	1 000	650	500
6	1.5	1.8	2.2	670	540	460
7	3.5	4.3	5.0	280	230	200
8	–	5.2	5.4	–	190	190
9	–	7.8	–	–	130	–
10	10.0	11	12.0	100	91	83
11	12.0	13	14.6	83	78	69
12	13.5	16	19.2	74	61	52
13	17.0	22	25.0	59	46	40
14	–	31	31.1	–	32	–
14	–	30	30.0	–	33	–
15	35.0	37	38.5	29	27	26
16	35.0	41	47.2	29	24	21
17	50.0	53	56.8	20	19	18
18	62.5	68	75.0	16	15	13
19	–	81	80.6	–	12	–
20	–	92	94.3	–	11	–
21	–	110	110.0	–	9	–
22	–	128	–	–	8	–
23	125.0	134	147.1	8	7	7
24	–	167	–	–	6	–
25	166.7	185	200.0	6	5	5
26	200.0	209	217.4	5	5	5
27	–	244	243.9	–	4	–
28	250.0	282	300.0	4	4	3
29	–	303	–	–	3	–
30	–	333	–	–	3	–
31	–	370	–	–	3	–
32	–	417	–	–	2	–
33	–	455	–	–	2	–
34	–	500	–	–	2	–
35	–	556	–	–	2	–
36	–	588	–	–	2	–
37	–	667	–	–	2	–
38	–	714	–	–	1	–
39	–	769	–	–	1	–
40	–	833	–	–	1	–
41	–	909	–	–	1	–

* Figures calculated on the basis of the publications of Klontz (1991), Mills (2001) and Hoitsy (2002).

Key data of different types and sizes of table fish production units of rainbow trout

TABLE A10.5
Production unit of 2.5 tonnes per year in tanks

Age groups	1st option						2nd option					
	Fish production		Rearing devices				Fish production		Rearing devices			
	No.	Weight (kg)	Total space m^2	Total space m^3	No. of devices	Size per device (m^3)	No.	Weight (kg)	Total space m^2	Total space m^3	No. of devices	Size per device (m^3)
Eyed eggs	14 000	–	0.5	–	2	–	7 000	–	0.25	–	2	–
Swim-up fry	13 000	–	2	1	2	0.5	6 500	–	1	0.5	2	0.25
Advanced fry (2 g/fish)	12 000	24	20	7	5	1.4	6 000	12	10	3.5	5	0.7
Subtotal	–	–	**22.5**	**8**	–	–	–	–	**11.25**	**4**	–	–
Fingerlings (25 g/fish)	11 000	280	30	20	5	4	5 500	140	15	10	5	2
Subtotal	–	–	**30**	**20**	–	–	–	–	**15**	**10**	–	–
Small table fish (250 g/fish)	10 000	**2 500**	125	125	5	25	5 000	1 250	62.5	62.5	–	–
Large table fish (500 g/fish)	–	–	–	–	–	–	5 000	**2 500**	62.5	62.5	–	–
Subtotal	–	–	**125**	**125**	**5**	**25**	–	–	**125**	**125**	**5**	**25**
Total (rounded)	–	–	**180**	**150**	–	–	–	–	**150**	**140**	–	–

TABLE A10.6
Production unit of 5 tonnes per year in tanks

Age groups	1st option						2nd option					
	Fish production		Rearing devices				Fish production		Rearing devices			
	No.	Weight (kg)	Total space		No. of devices	Size per device (m^3)	No.	Weight (kg)	Total space		No. of devices	Size per device (m^3)
			m^2	m^3					m^2	m^3		
Eyed eggs	28 000	–	1	–	2	–	14 000	–	0.5	–	2	–
Swim-up fry	26 000	–	4	2	2	1.0	13 000	–	2	1.0	2	0.50
Advanced fry (2 g/fish)	24 000	48	40	14	5	2.8	12 000	24	20	7.0	5	1.4
Subtotal	–	–	**45**	**16**	–	–	–	–	**22.5**	**8**	–	–
Fingerlings (25 g/fish)	22 000	560	60	40	5	8	11 000	280	30	20	5	4
Subtotal	–	–	60	40	–	–	–	–	30	20	–	–
Small table fish (250 g/fish)	20 000	5 000	250	250	–	–	10 000	2 500	125.0	125.0	–	–
Large table fish (500 g/fish)	–	–	–	–	–	–	10 000	5 000	125.0	125.0	–	–
Subtotal	–	–	**250**	**250**	**5**	**50**	–	–	**250**	**250**	**5**	**50**
Total (rounded)	–	–	**360**	**310**	–	–	–	–	**300**	**280**	–	–

TABLE A10.7
Production unit of 2.5 tonnes per year in fish ponds

Age groups	1st option						2nd option					
	Fish production		Rearing devices				Fish production		Rearing devices			
	No.	Weight (kg)	Total space		No. of devices	Size per device (m^3)	No.	Weight (kg)	Total space		No. of devices	Size per device (m^3)
			m^2	m^3					m^2	m^3		
IN TANKS												
Eyed eggs	14 000	–	0.5	–	2	–	7 000	–	0.25	–	2	–
Swim-up fry	13 000	–	2	1	2	0.5	6 500	–	1	0.5	2	0.25
Advanced fry (2 g/fish)	12 000	24	20	7	5	1.4	6 000	12	10	3.5	5	0.7
Total	–	–	**22.5**	**8**	–	–	–	–	**11.25**	**4**	–	–
IN PONDS												
Fingerlings (25 g/fish)	11 000	280	56	70	5	14	5 500	140	28	35	5	7
Subtotal	–	–	**56**	**70**	–	–	–	–	**28**	**35**	–	–
Small table fish (250 g/fish)	10 000	2 500	400	400	–	–	5 000	1 250	160	200	–	–
Large table fish (500 g/fish)	–	–	–	–	–	–	5 000	2 500	160	200	–	–
Subtotal	–	–	**400**	**400**	**4**	**100**	–	–	**320**	**400**	**4**	**100**
Total (rounded)	–	–	**460**	**470**	–	–	–	–	**350**	**440**	–	–

TABLE A10.8
Production unit of 5 tonnes per year in fish ponds

Age groups	1st option						2nd option					
	Fish production		Rearing devices				Fish production		Rearing devices			
	No.	Weight (kg)	Total space		No. of devices	Size per device (m^3)	No.	Weight (kg)	Total space		No. of devices	Size per device (m^3)
			m^2	m^3					m^2	m^3		
IN TANKS												
Eyed eggs	28 000	–	1	–	2	–	14 000	–	0.5	–	2	–
Swim-up fry	26 000	–	4	2	2	1.0	13 000	–	2	1	2	0.50
Advanced fry (2 g/fish)	24 000	48	40	14	5	2.8	12 000	24	20	7	5	1.4
Total	–	–	**45**	**16**	–	–	–	–	**22.5**	**8**	–	–
IN PONDS												
Fingerlings (25 g/fish)	22 000	560	112	140	5	28	11 000	280	56	70	5	14
Subtotal	–	–	**112**	**140**	–	–	–	–	**56**	**70**	–	–
Small table fish (250 g/fish)	20 000	5 000	800	800	–	–	10 000	2 500	400	400	–	–
Large table fish (500 g/fish)	–	–	–	–	–	–	10 000	5 000	400	400	–	–
Subtotal	–	–	**800**	**800**	**4**	**200**	–	–	**800**	**800**	**4**	**200**
Total (rounded)	–	–	**910**	**940**	–	–	–	–	**860**	**870**	–	–

TABLE A10.9
Checklists for planning and evaluation of investment and production

1		Engineering design
2		Technological design
3		Land
4		Permissions
5		Taxes
6		Earthworks
7		Tanks
8		Concrete structures
9		Buildings
10		Roads
11		Fences
12		Machines
13		Vehicles
14		Fittings and devices
15		Apparatus
16		Equipment
17		Tools
18		Furniture
19		Broodfish
20		Miscellaneous

Items of production costs

1		Fish (eggs, fry, fingerling)
2		Feeds
3		Materials
4		Energy (electricity, fuel, etc.)
5		Labour
6		Maintenance
7		Miscellaneous
8		Bank fees
9		Insurance

Production-related expenses

1		Depreciation
2		Taxes

This paper is a basic guide to starting and successfully practicing small-scale rainbow trout farming, summarizing all essential technical information important for small-scale trout production. It includes general information on efficient treatment of trout farm effluents, taking into consideration the need to protect mountainous regions where water resources could support profitable trout farming. The aim is to guide the reader through the necessary technical information, related practical solutions and the steps of preparation of both investment in and day-to-day operation of a small-scale rainbow trout farm. It includes a glossary and illustrations for easy understanding.

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