DRAFT CODE OF PRACTICE

FOR THE CARE AND HANDLING OF

FARMED SALMONIDS

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Introduction

As a nationally developed welfare standard for farmed salmonids, this Code of Practice is the first of its kind in Canada. In developing this Code, the Code Development Committee relied on research, veterinary expertise, and practical experience of those responsible for the day-to-day care of fish. The Code aims to provide feasible and scientifically informed approaches to fish husbandry that will contribute to a sustainable and internationally competitive Canadian aquaculture industry. As much as possible, user friendly tools have been included in the Code to support its use in any production context.

The public and industry alike are increasingly concerned about the welfare of farmed fish. There are both practical and moral reasons for taking fish welfare seriously. Good production and good flesh quality often follow good welfare and are all integral to the success of the farm. Most importantly, optimizing fish welfare is the ethical thing to do for the fish in our care. It is essential that staff managing farmed fish are aware of the importance of welfare as an integral part of production.

The Five Freedoms (below) provide a framework for assessing fish welfare (1). At every stage of production the welfare of fish should be considered in terms of these freedoms:

- Freedom from Hunger and Thirst
- Freedom from Discomfort
- Freedom from Pain, Injury or Disease
- Freedom to Express Normal Behaviour
- Freedom from Fear and Distress

This Code of Practices pertains to farmed salmonids (i.e. trout, salmon, and charr) in all stages of production, including hatchery, nursery, grow-out, transportation, and slaughter. While the vast majority of the sector is in salmonid production and is therefore covered by this Code (approximately 95%), the Code Development Committee recognizes the growing diversity of farmed fish species and encourages the timely development of Codes of Practice for all farmed fish species in Canada. This Code does not apply to commercial or recreational fishing, conservation aquaculture, or wild stock enhancement.

While cleaner fish are outside of the scope of this Code of Practice (cleaner fish are typically wrasse or lumpfish, and are not part of the salmonid family), producers who use cleaner fish to control sea lice are strongly encouraged to adapt the farmed salmonid Code to cleaner fish management where applicable. Resources on the care of cleaner fish are available in *Appendix K – Resources for Further Information*.

All applicable provincial/territorial and federal acts and regulations continue to take precedence and anyone establishing or assuming management of a hatchery, nursery, farm, or transport or slaughter service will need to be familiar with, and follow, existing legislation.

Glossary

Alevins: larval stage fish not yet ready for first feeding (with yolk sacs still visible and used for nutrition).

All-in/all-out: a production strategy whereby all fish are moved into and out of facilities or production phases at the same time.

Anesthesia: temporary induction of loss of sensation or awareness. Fish are generally considered to be anesthetized when they lose consciousness. (See also “Sedation.”)

Animal welfare: an animal is in a good state of welfare if (as indicated by scientific evidence) it is healthy, comfortable, well nourished, safe, able to express innate behaviour, and if it is not suffering from unpleasant states such as pain, fear, and distress (2). Animal welfare refers to the state of an animal; the treatment that an animal receives is covered by other terms such as “animal care.”

Biodensity (stocking density): the fish biomass per unit volume of water, typically expressed in kg/m^3. (See also “Biomass.”)

Biofouling: the accumulation of microorganisms, algae, plants, or small aquatic animals on rearing units or the equipment within.

Biomass: the number of fish multiplied by the average fish weight, divided by the volume of tank or pen. (See also “Biodensity.”)

Biosecurity: measures intended to reduce the risk of the introduction, establishment, and spread of animal diseases.

Broodfish: adult fish of reproductive age that are used to produce eggs and sperm from which juvenile fish result.

Cleaner fish: species of fish, such as wrasse or lumpfish, which are stocked with farmed fish as a biological control measure for sea lice.

Cleaning: physical removal of visible wastes such as biofilm, debris, dirt, and dust often with soap and water. (Contrast with “Disinfection.”)

Competent: demonstrated skill and/or knowledge in a particular topic, practice, or procedure that has been developed through training, education, experience, and/or mentorship.

Compromised animals: in the context of transport, fish that have a reduced capacity to withstand transportation due to weakness, illness, injury, or other cause (3). (Contrast with “Fit animals” and “Unfit animals.”)

Crowding: the process in which the area available to the fish is temporarily reduced, usually to facilitate the removal of fish from a rearing unit.

Degree days: a value used to estimate and predict the amount of time for fish development, growth, and other physiological processes. The number of degree days is calculated by multiplying the average temperature by the number of days. For example, 300 degree days may be 30 days at 10°C, 100 days at 3°C, or any other multiple that results in 300. Throughout this Code, degree days are estimated using the Celsius scale.

Disease: any physiological alteration of the normal state of an animal that interrupts or disturbs its vital functions and causes a pathological change. Infectious diseases may be caused by bacteria, virus, fungus, parasites, or other organisms.

Disinfection: the application of procedures or products intended to effectively inactivate disease-carrying microorganisms on equipment or facilities. (Contrast with "Cleaning.")

Distress: distress results when an animal's response to stimuli interferes with its well-being and comfort. This definition may differ from how "distress" is used in some animal welfare legislation.

Euthanasia: inducing the humane death of one or a small number of fish in a way that minimizes or eliminates distress and suffering (4).

Eyed eggs: eggs that have reached the stage of development where the black spot of the eye is clearly visible (approximately 220–250 degree days after spawning).

Fallowing: the practice of leaving rearing units empty of fish for a period of time to reduce the likelihood of disease transmission or parasite infestation between groups (5).

Fingerling: fish that have reached the stage where the fins can be extended and scales have started developing throughout the body. In this stage, the fish are typically the size of a finger.

Fit animals: fish that can withstand the stress of transportation without experiencing suffering and that are expected to arrive at their destination in good condition. (Contrast with "Compromised animals" and "Unfit animals.")

Fry: fish starting from first feeding up to 1 gram.

Grading: sorting fish by size.

Hatchery: a site dedicated to artificial breeding, hatching, and rearing through to the early life stages of fish.

Lux: a standardized unit of measurement for the intensity of light, as perceived by the human eye.

Mass depopulation: humane termination of a population or large numbers of fish. Depopulation may be necessitated by detection of a regulated disease, the need to alleviate suffering, or an untreatable disease affecting large numbers of fish (6).

Morbidity: the condition of being diseased.

Moribund: an animal whose condition is in a state of terminal decline; in a state of dying.

Nursery: a site that raises fish starting at post hatching until transfer to grow out.

Opercular rate: the number of times the operculae (gill covers) open and close during a specified time period. For example, an opercular rate of 10 per minute means that the operculae opened and closed 10 times over a period of a minute.

Parr: fish that are greater than 1 gram and up to the start of smoltification. Parr are characterized by the appearance of vertical lines on each side of their body.

Pathogen: a bacterium, virus, or other microorganism or agent that can cause disease.

Quarantine: maintaining a group of aquatic animals in isolation with no direct or indirect contact with other aquatic animals, in order to undergo health observation for a specified length of time and, if appropriate, testing and treatment, including water treatment (5).

Sea lice: parasitic copepods commonly found on wild salmon and a variety of other fish species that may transfer lice to farmed salmon.

Sedation: physiological state where fish are lightly anesthetized and show reduced activity but normal equilibrium, opercular rate, and muscle tone. (See also "Anesthesia.")

Shocking eggs: the mechanical process of turning unfertilized eggs white so that they can be separated from fertilized eggs. Eggs are shocked when they reach the eyed stage.

Slaughter: humane killing of animals intended for food.

Smoltification: a series of physiological, and behavioural changes some young salmonids undergo to adapt from living in freshwater to seawater (also called parr-smolt transformation).

Smolts: fully smolted juvenile fish. These fish are silver in appearance.

Standard operating procedure: written step-by-step instructions describing how a particular task is to be completed. Standard operating procedures typically include specific assignment of responsibilities, workflows, desired outcomes, and contingencies.

Swim-up stage: the stage of development when an alevin exhibits deliberate swimming motion and must swim to the water surface to fill its swim bladder.

Transportation process: any stage in preparing for or transporting fish, i.e. loading, confinement, transporting, and unloading.

Triploid fish: fish that are sterile as a result of a procedure performed on the eggs. Triploid fish possess three sets of chromosomes instead of the normal two.

Unconsciousness: the point at which an animal can no longer perceive and respond to its environment (e.g. light).

Unfit animals: in the context of transport, fish exhibiting any signs of weakness, illness, injury or other condition that indicate that they cannot be transported without suffering (3). (Contrast with "Compromised animals" and "Fit animals.")

Veterinarian-client-patient relationship (VCPR): the basis for interaction among veterinarians, their clients, and their clients' animals. The VCPR is specifically defined in provincial veterinary acts but, generally, a VCPR has been established when the veterinarian has examined the fish or visited the site; the veterinarian has assumed responsibility for making clinical judgments related to the health of the fish; and the client has indicated a willingness to follow the veterinarian's instructions.

1. Knowledge and Skills of Hatchery, Nursery, and Farm Personnel

The people who care for fish at any life stage have an important impact on their welfare (7). Personnel that work directly with eggs and fish are often the first to identify possible concerns, and it is essential that they are competent in their assigned duties. Research in several farmed animal species shows that attitudes and beliefs about animals and the importance of routine care influence the way people interact with animals and the diligence with which they carry out their tasks (7). These factors also contribute significantly to the variation across farms in productivity and other performance metrics (7).

Eggs and young fish are at the most critical of all life stages. Not only does the care they receive in the hatchery/nursery directly impact their welfare during this stage of production, but it also has significant and lasting influence on their welfare in all subsequent life stages. Attentive and skillful husbandry during these early life stages is integral for success throughout the grow-out period.

Competency of personnel involved in fish transport is covered in *Section 7 – Transportation*.

REQUIREMENTS

- **Personnel who care for eggs or fish must have the competence to properly carry out the procedures and practices they are responsible for.**

RECOMMENDED PRACTICES

a. develop and implement a written animal welfare policy outlining the company's commitment to responsible care of eggs and fish (see *Appendix A – Sample Fish Welfare Policy*)
b. participate in continuing education activities related to animal care and welfare
c. develop and implement detailed standard operating procedures to facilitate training and ensure consistency in the delivery of the procedures
d. document training and certifications completed (see *Appendix B – Sample Training Log*)
e. routinely assess compliance to standard operating procedures
f. update standard operating procedures at least annually (or whenever important improvements are made to procedures) and promptly communicate changes to personnel (Appendix C provides a sample form to help track these activities)
g. identify managers or mentors that personnel can approach with questions/concerns about the care of eggs and fish

2. Rearing Units

A variety of rearing unit types and sites are used in the farmed salmonid industry, ranging from ponds, sea and lake net pens, and land-based flow-through and recirculating systems. Despite this diversity, the same main factors need to be considered when designing any rearing unit.

2.1 Site Selection

Environmental conditions (e.g. potential for storms) are important to consider when selecting a site, as is the probability of events that may result in poor water quality (e.g. flooding, plankton blooms). Long term availability of water for land-based sites is also a critical consideration. When it exists, consulting historical data (e.g. hydrographic, oceanographic) and traditional knowledge will help to determine whether a location is appropriate. Suitability may change over time with decreasing oxygen or increasing water temperatures, so site risks need to be continually reassessed.

REQUIREMENTS

- **Site selection considerations must include an assessment of water quality and environmental risks.**
- **Where it exists, historical data (e.g. hydrographic, oceanographic) must be consulted to determine site suitability and understand seasonal changes.**
- **Site suitability must be routinely evaluated as it may change over time. Management practices must change in relation to changes in site condition.**

RECOMMENDED PRACTICES

a. locate enclosures so that they are unlikely to be damaged by adverse weather or to experience events like plankton blooms
b. plan ahead to mitigate any negative effects that adverse weather conditions, including those associated with climate change, might have on the welfare of fish
c. identify other sites for net pens if algae blooms, superchill, or periods of high water temperatures are frequent

2.2 Rearing Unit Design

Water Quality and Water Current Speed

The amount of control over water quality parameters depends on the type of rearing unit. Water supply needs to be assessed for contaminants and to ensure there is sufficient capacity. Water current speeds are particularly important in net pens, where they influence water exchange. Low speeds can lead to low oxygen events and hypoxia in fish, especially at high density and high temperatures. High speeds may cause net pens to become deformed, reducing the pen volume and potentially leading to crowding, entanglement, and injury. High current speeds may also prevent fish from maintaining their position in the school or water column. In extreme cases, high water current speeds can lead to fish becoming exhausted.

Life Support Redundancy and Emergency Procedures

All rearing units benefit from having back-up life support systems and emergency procedures, but these systems are particularly vital in aquaculture systems where biodensities are high and water quality ranges are narrow. Life support systems need to be maintained and tested regularly and emergency procedures should be reassessed frequently. It is necessary to know how long water quality will be maintained in the event of a power failure to evaluate the level of life support redundancy required (e.g. what size of generator is needed and how much fuel).

Containment and Exclusion

Escaped farm fish may experience poor welfare. Rearing units with lids or appropriate netting help prevent fish from escaping. Inlets and outlets should be designed to prevent escape of farm fish as well as entry of wild stock.

Noise, Vibrations, and Electrical Current

Equipment used in aquaculture produces vibrations and ambient noise at low, sustained frequencies (e.g. aerators, pumps, harvesters, blowers). Loud, intermittent noises with high levels of vibration are disruptive to fish. Effects depend on the intensity of the noise but may include hearing impairment, behavioural changes, and death (8). Aquaculture production also involves the use of electrical equipment (e.g. electrical feeders) that may produce stray electrical currents. Electrical current is highly noxious to fish and may lead to injury or mortality.

Environmental Enrichment

The design of rearing units may result in fish being unable to perform a full repertoire of natural behaviour, potentially causing increased stress and aggression. The use of environmental enrichment such as dark backgrounds, tank floor substrate, and shelters has the potential to reduce aggression (9, 10, 11). Objects like artificial turf mats or substrates have been shown to increase survival rates of alevins and fry (12). Changes made to a fish's environment need to be monitored to ensure that they positively enhance welfare and do not cause health or production issues.

REQUIREMENTS

- **Rearing unit design considerations must include an assessment of water quality.**
- **Emergency procedures, relevant to the farm's location and type of rearing unit, must be developed and communicated to personnel.**
- **Rearing units must have systems in place to mitigate fish escape and wild fish and predator entry.**
- **Rearing units must not contain sharp protrusions or abrasive surfaces that could injure fish.**
- **Netting and screens must be a suitable size for the fish being held to prevent escape, entanglement, entrapment, and injury.**
- **Netting and screens must be regularly checked for holes and maintained in good condition.**
- **Net pens must be adequately tensioned and of a weight that prevents distortion and associated crowding, entanglement, or injury.**
- **Flow rate must allow for fish to hold their desired position in the water column and for water quality to be maintained.**

RECOMMENDED PRACTICES

a. consider using environmental enrichment or other design features that allow fish to perform a range of natural behaviours (e.g. shelters, artificial substrates)
b. consider the following design elements when developing a rearing unit:
    - fish welfare
    - fish behaviour
    - water treatment
    - water volume and flow
    - access to fish for monitoring
    - protection from adverse weather
    - redundancies in life support
    - feed delivery
    - reducing noise pollution and vibrations
    - ease of mortality collection and disposal
    - reducing pathogen introduction and spread
c. monitor for and eliminate stray voltage within the rearing unit
d. ensure secondary life support systems capable of maintaining aerated and filtered water are present in all rearing units

2.3 Water Quality

Water quality is fundamental to the welfare of farmed fish. Poor water quality elicits a stress response in fish (13). When the conditions become too challenging or prolonged, fish cannot maintain homeostasis and experience chronic stress which can impair immune function, growth, and reproductive function (14). The potential for serious welfare issues related to water quality is highest in intensive recirculating aquaculture systems (RAS) where fish are raised at high densities in highly controlled environments where margins for error are narrow.

Oxygen

Monitoring of oxygen is essential in all aquaculture systems. Injection of supplemental oxygen to maintain adequate levels is needed in some systems, such as RAS. Oxygen levels in water decrease as temperature increases, so oxygen levels should always be assessed in conjunction with temperature (13). Consumption of oxygen is also affected by body mass, growth rate, feeding rate, activity and stress (15). An increased ventilation rate or gasping at the surface may indicate severely low levels of oxygen, whereas gas bubble disease may be seen if oxygen levels are extremely high (supersaturation) (16).

Carbon Dioxide

High levels of carbon dioxide are most likely to occur in RAS, and can result in decreased oxygen uptake, decreased growth rates, kidney damage, and cataracts (16). Signs of carbon dioxide toxicity include slowed respiration and fish laying on the bottom of the tank.

Ammonia, Nitrite, and Nitrate

Ammonia is produced by fish as well as by decomposing feed and feces. It is converted by bacteria to nitrite, then nitrate. Nitrite and unionized ammonia are toxic at high levels and long-term exposure can result in reduced growth, disease resistance, and fertility (15). Signs of ammonia toxicity include reduced swimming performance, erratic swimming, increased gill ventilation, gasping, and loss of equilibrium (13). Nitrate is relatively non-toxic but can cause problems such as poor growth, if allowed to accumulate (16).

pH

The pH of water will vary significantly depending on its source. Agricultural runoff, storms, or other factors may cause temporary fluctuations in pH. Very low pH (below 5.0) can be lethal for salmonids (15).

Temperature

Salmonids rely on their environment and behaviour to maintain their body temperature. Preferred temperature range varies significantly with species and life stage. Temperature range may be manipulated to alter growth rates, but serious welfare issues, including mortality, can occur if this is done inappropriately (16).

Suspended Solids and Turbidity

High levels of suspended solids can have negative effects on gill health and function, compromising oxygen transfer and providing a habitat for the growth of pathogens (17). Increased suspended solids result in increased turbidity and biofouling and make it harder to observe fish. Variation in the formulation of commercial feeds may result in diarrhea which contributes to turbidity (16).

Hydrogen Sulphide

Hydrogen sulphide is formed by decomposition of organic matter in anoxic areas, like sludge or sediment buildup in tanks (16). It is highly toxic to fish even in very small quantities, with the risk of build-up being higher in seawater (16). Hydrogen sulphide interferes with respiration, so the initial sign of poisoning is an increased respiratory rate (13). Routine cleaning and sediment removal from rearing units reduce the risk of poisoning.

REQUIREMENTS

- **Oxygen must be monitored daily at the effluent, or the point of lowest expected oxygen, in each fish holding unit.**
- **Water temperature must be monitored daily in all systems.**
- **If water temperature or oxygen levels are outside of the appropriate range and cannot be corrected, non-urgent procedures that may cause additional stress (e.g. handling), must be postponed until parameters are back within range.**
- **Monitoring and mitigation plans for plankton must be in place for marine systems.**
- **If abrupt changes in water quality or behaviour suggesting poor water quality (e.g. fish gasping due to low oxygen levels) occur, corrective action must be taken.**

RECOMMENDED PRACTICES

a. keep water quality parameters within the following optimal ranges:
   - Oxygen: 80–100%
   - Carbon dioxide: below 10 mg/L
   - Ammonia (unionized): below 0.0125 mg/L
   - Nitrites: below 0.2 mg/L
   - Nitrates: below 100 mg/L
   - pH: 6–8.5
   - Temperature: 4–18°C

b. be aware of all other water quality parameters in a system and routinely monitor for negative outcomes

c. use automated alarm systems to monitor water quality and enable early identification and correction of issues

d. monitor and have mitigation plans in place for turbidity and total dissolved solids

e. avoid build-up of biofouling in rearing units (e.g. wash or change out nets frequently, use biofouling resistant nets, clean pond and tank surfaces frequently)

f. monitor pH closely in situations where it may drop quickly (e.g. before and during snow melt, during a heavy downpour)

g. monitor oxygen levels continuously in RAS

h. avoid abrupt changes in water quality when taking corrective action, as fish may be slow to adapt to the change

i. monitor ammonia, nitrite, and nitrate concentrations several times a week in RAS. Increase to daily monitoring when using medications, in the event of an increase in mortality, or when changing feeding programs
j. increase monitoring during any major system change (e.g. increase monitoring of pH and oxygen in net pens during algae blooms)
k. ensure there are no areas of very low oxygen or sludge buildup within the rearing unit

2.4 Lighting

Photoperiod and light intensity are key management tools in salmonid production. Artificial lighting is used to control photoperiod in order to induce smoltification, advance or delay the timing of spawning, manipulate sexual maturation, and promote fish growth. Various lighting regimens are used for these purposes, including extended day length, reduced day length, or continuous light (i.e. no dark period in a 24-hour cycle). Continuous lighting is also used to prevent suffocation in the early swim-up stage and to avoid maturation and associated disease vulnerability (16).However, continuous lighting is also associated with several negative effects including neurological development issues, reduced bone strength, poor smolt quality, failed smolting, and failed spawning (18, 19, 20, 21).

Light intensity and daylight can be manipulated by increasing or decreasing the number of lights on the farm, or by changing the strength and type of the lights. Light intensity is affected by the distance between the fish and the light source, the clarity of the water, and the stocking density within the rearing unit. It is important to avoid exposing fish to sudden changes in light intensity, either more or less, as this may cause fear responses, increased oxygen consumption, injuries, or suffocation (22, 23, 24). In order to habituate fish to a change in light intensity, fish need to be gradually exposed to these lighting levels before being transferred to new environments.

Excessive exposure to ultraviolet (UV) light from the sun may damage the eyes of fish resulting in cataracts or ulcers and may cause sunburn.

Light emitting diodes (LEDs) offer a new form of lighting technology currently being developed for the fish farming industry (25). LED technology is fast evolving and may offer an alternative that is more in tune to environment and species sensitivities (25), but the full impact on fish welfare is not yet known.

REQUIREMENTS

- **Rapid changes in light intensity that result in injury, mortality, or suffocation must be avoided.**
- **As of the publishing of this Code, all sites that are newly built, substantially renovated, or brought into use for the first time must include lighting systems that gradually change in light intensity.**

- **When used, lighting control systems must be inspected regularly and maintained in good working order.**

RECOMMENDED PRACTICES

a. set lights to phase on and off slowly over several minutes
b. remove lids from tanks gradually
c. slowly transition fish to new lighting conditions before transferring them to a new environment (e.g. moving to net pens)
d. prevent eye and skin damage from UV light by ensuring adequate enclosure depth or by using tank lids
e. consider welfare impacts before implementing a continuous lighting regimen. Where feasible, provide periods of darkness
f. monitor for any unwanted outcomes when introducing LED lighting into a rearing unit

2.5 Biodensity

The impact of biodensity on fish welfare is dependant on several variables, including species, life stage, water quality, feed access, and the ability to control the environment within different types of rearing units. In general, the potential for negative welfare is increased with high densities (26). Issues include stress and increased susceptibility to disease, unequal feed access, and reduced growth rate, feeding efficiency and fin quality (26). However, as is illustrated in *Appendix D – Relationship between Biodensity and Welfare Outcomes*, high density does not always result in negative welfare outcomes if other variables are controlled (e.g. water quality, fish health, stress).

On farms, maximum biodensities range between approximately 10–25 kg/m^3 in net pens (i.e. an upper limit of 2.5% fish, 97.5% water) and 20–100 kg/m^3 in land-based systems (i.e. an upper limit of 10% fish, 90% water). Semi-contained systems fall somewhere between these ranges depending on their design and the degree of control over water quality. Given the interaction of variables involved in determining an appropriate biodensity, and the scope of species and rearing units covered in this Code of Practice, it is not possible to provide a list of density ranges that would both account for all of these factors and guarantee positive health and welfare outcomes. The overall condition and behaviour of the fish should serve as the main considerations when assessing welfare in relation to stocking density. *Appendix E – Welfare Indicators* provides an example of how various indicators may be used to assess fish welfare including in relation to stocking density. Biodensity should always be assessed along with other management practices that may cause changes in behaviour and condition.

Density changes as fish grow and therefore needs to be assessed frequently. Density is measured using the following calculation: Biomass = (number of fish × the average fish weight) / volume of tank or pen.

The number of fish in a unit should be counted when a tank or pen is first stocked. Accuracy of counts may be validated with a second method of counting or by putting a predetermined number of fish through a counter to check its accuracy. Tracking the average weight of the fish over time as well as the number of mortalities removed from rearing units is also important for ensuring the accuracy of biodensities.

REQUIREMENTS

- **If emaciation and/or issues with fin and skin condition or feeding response occur, biodensity must be assessed as a potential contributing factor and corrective action must be taken.**
- **Biodensity must be assessed at least once a month in all rearing units to ensure it remains appropriate relative to any changing conditions.**

RECOMMENDED PRACTICES

a. establish a baseline for expected mortality and morbidity rates, growth rates and acceptable water quality data; monitor for changes in trends; and investigate any deviation from expected rates (*Appendix E – Welfare Indicators* provides a sample approach and suggested benchmarks)
b. aim for a biodensity that produces outcomes in alignment with the green column of *Appendix E – Welfare Indicators*
c. ensure fish counts are accurate when calculating biomass. Validate counts where possible
d. weigh fish at the same time as other procedures to minimize the frequency of handling
e. consider the use of technologies that allow biomass to be calculated without handling fish (e.g. biomass frames, stereo camera-based systems)

3. Husbandry Practices

3.1 Husbandry Practices for Specific Life Stages and Triploid Fish

3.1.1 Egg Management

Proper incubation and handling of eggs promotes healthy embryo development, minimizes embryo mortality and deformity, and promotes good welfare in all subsequent life stages. Eggs require careful handling and care throughout all development stages but are particularly susceptible to damage before they reach the eyed stage.

Incubating eggs in consistent darkness or low light intensities results in better survival and larger alevins (27).

Optimal egg incubation temperatures vary somewhat amongst salmonids and stages of egg development (see Table 3.1). Temperatures that are too high or low or that fluctuate too much are associated with increased rates of jaw, fin, vertebral, and other deformities in developing fish (28).

Prompt and careful removal of dead eggs and egg surface disinfection, as appropriate, helps prevent the establishment of fungal infection and/or its spread to live eggs (27, 29).

Table 3.1 – Optimal Egg Incubation Temperature Ranges*

	Charr	Trout	Salmon
Uneyed	2–4°C	4–14°C	4–8°C
From eyed stage	2–8°C	4–14°C	8–10°C

*the exact ideal temperature varies by strain of fish

REQUIREMENTS

- **Eggs must be incubated, cared for, and handled in ways that promote healthy embryos.**
- **Incubators must be in good working condition to prevent injury or death and prevent eggs from falling out.**
- **Incubators with eggs must never be handled in a manner likely to damage the eggs.**
- **Eggs must be disinfected after fertilization.**

RECOMMENDED PRACTICES

a. follow the incubator manufacturer's recommendations on stocking rates for eggs
b. minimize movement of eggs between the fertilization and the eyed stage

c. maintain the optimal incubation temperature for the species and life stage (see Table 3.1, above)
d. protect eggs from dramatic fluctuations in water temperature (no more than +/- 1°C per hour, as a guide)
e. keep eggs under a low light intensity (e.g. <5 lux) (27, 30)
f. avoid exposing eggs to abrupt fluctuations in light intensity
g. promptly remove dead/unviable eggs at the earliest stage possible (ideally not before approximately 250 degree days after fertilization) (29)
h. ensure removal of dead/unviable eggs is done with minimal disturbance to live eggs
i. establish and implement site-specific protocols for keeping the surface of eggs clean and monitoring egg mortality and fungal growth
j. if shocking eggs against a hard surface, ensure sufficient water flow and have sufficient water in the container to mitigate the intensity of the shock

3.1.2 Broodfish

Broodfish are often exposed to frequent handling as personnel select for specific traits or assess fish for maturity. These handling events likely occur during sensitive time periods of egg development and release, and therefore handling of individual fish needs to be done with care.

Some broodfish are tagged for identification and sampled for genotyping. Genotype sampling is usually done by clipping a small amount of tissue from either the caudal or adipose fin or through a scale scrape. Tagging and genotype sampling may result in stress and/or pain, so these procedures must only be performed by trained individuals on anesthetized fish.

Synchronizing maturation is done primarily to increase egg and fingerling supply throughout the year. Depending on the rearing environment and species, production of monosex or the use of hormones may be necessary to synchronize maturation between males and females. If photoperiod manipulation is used to alter the time of maturation, consistent and accurate changes in day length are recommended.

Eggs may be collected by hand pressure, compressed air, or saline flushing. In order to facilitate handling, broodfish that spawn more than once are sedated or anaesthetized prior to gamete collection. To reduce the risk of transmission of pathogens between batches of eggs or milt, collection needs to be performed in a hygienic manner (refer to *Section 5 – Health Management*).

REQUIREMENTS

- **Personnel involved in spawning, tagging, and fin clipping must be competent in the technique prior to performing the procedures on broodfish.**
- **Eggs and milt must be collected using only gentle pressure.**

- **If spawning is terminal, broodfish must be euthanized in a humane manner prior to spawning. Refer to *Section 6 – Euthanasia, Slaughter, and Mass Depopulation*.**

RECOMMENDED PRACTICES

a. perform tagging or marking of broodfish in a manner that will not have any long-term adverse effects on fish behaviour, health, feeding, or movement
b. remove no more than the necessary amount of tissue when performing a fin clip or scale scrape for genotype sampling
c. use the following techniques when inserting tags:
   - ensure fish have empty guts prior to tagging (refer to *Section 4.3.3 Feed Withdrawal*)
   - ensure the size of the tag is appropriate for the size of fish
   - use a sharp needle for insertion of the tag
   - disinfect the needle between each fish
d. maintain accurate and complete records for all broodfish procedures to guide future collections
e. ensure any gloves worn while handling broodfish minimize slipping, prevent scale loss, and do not damage the mucous layer
f. use automatic lighting timers when using photoperiod manipulation to alter the time of maturation

3.1.3 Triploid Fish

Triploids are desirable in certain production systems because they are infertile, which minimizes the impact of escapees on wild populations (31). In addition, female triploids are beneficial because they do not develop secondary sexual characteristics and associated issues (31). It is common practice in some systems to use all female production paired with triploidy, and the use of either single sex populations or triploids is legally mandated in some provinces.

The procedure performed on eggs to produce triploids may be associated with high rates of mortality and deformity if not done properly (31), so careful training and technique is required. Induction of triploidy by pressure treatment is associated with lower mortality at the eyed stage or at hatching, and lower rates of deformities at hatching compared to induction of triploidy by heat treatment (30).

It is particularly important to rear triploid fish in optimal water quality and avoid conditions that may cause chronic stress (e.g. high temperature combined with low oxygen levels, and/or changes in salinity) (31).

When reared together with diploids, triploids may show reduced growth rates and increased fin erosion, possibly due to the generally less aggressive demeanor often observed in triploids (31).

There is recent evidence that deformities in triploid adult Atlantic salmon can be reduced with the use of specific triploid diets as there are different nutritional requirements between ploidies (31).

REQUIREMENTS

- **To reduce the rate of mortalities and deformities, personnel responsible for performing triploid production on eggs must be competent in the technique.**
- **The rearing environment and husbandry practices must be adapted to suit the specific needs of triploid fish.**

RECOMMENDED PRACTICES

a. improve triploid production techniques if deformity or larval mortality rates increase (31)
b. avoid using heat treatment as the technique for producing triploid fish
c. avoid rearing diploids and triploids in the same rearing unit (31)
d. frequently monitor triploid fish to ensure any issues can be addressed promptly (the window to correct issues is narrower with triploid fish)
e. ensure, as best as possible, that triploid fish are reared in units with minimal fluctuation in water temperature and high oxygen levels (10–50% higher than diploid units)
f. avoid rearing triploid fish in environments that have high water temperatures or high salinity (31)

3.2 Handling

Although handling is necessary for certain procedures that contribute to fish welfare, it is stressful for fish. Fish may be more susceptible to handling injuries depending on their life stage (i.e. first feeding, late stages of sexual maturation), health status (e.g. gill damage, concurrent disease), and environmental factors (e.g. hypoxia, extreme water temperatures).

REQUIREMENTS

- **Personnel must be competent in techniques used to handle fish in all life stages.**
- **Fish must have their body supported when they are lifted and carried and must never be lifted or carried by only the head, tail, or gills.**
- **Fish must be handled in a manner that does not cause suffering, injury, or death. Personnel must not beat, strike, whip, kick, sweep, or drag fish.**
- **The time that fish are out of water must be minimized (i.e. only as long as necessary to carry out the procedure).**
- **Loading density in hand nets must prevent suffocation and injury.**
- **Protocols outlining when handling fish will be delayed due to poor health status (e.g. gill disease) or poor water quality conditions (e.g. low oxygen, plankton bloom) must be developed and followed.**

RECOMMENDED PRACTICES

a. develop and implement a standard operating procedure for handling fish at each life stage
b. have sufficient personnel to perform procedures in a timely manner and any necessary tools/equipment ready before fish are handled
c. strive to return fish to the water in less than 30 seconds (32, 33)
d. whenever possible, run water over the gills when handling fish out of water
e. ensure any gloves worn while handling fish minimize slipping and mucous loss and prevent scale loss

3.2.1 Sedating and Anesthetizing Fish

Section 3.2.1 pertains to temporarily sedating/anesthetizing fish prior to certain husbandry procedures to minimize the harms associated with their increased activity during handling. *Section 6 – Euthanasia, Slaughter, and Mass Depopulation* addresses sedating/anesthetizing fish in the context of humane killing.

Features of an appropriate sedative/anesthetic include: (34)

- short induction time
- straightforward to administer to ensure correct and consistent use
- short recovery time relative to depth of sedation/anesthesia (fish can generally be considered recovered when they have equilibrium back)

Table 3.2 Stages of sedation and anesthesia (35)

Stage	Descriptor	Fish response	Some examples of procedures appropriate for a given stage
1	Lightly sedated	Disoriented; reduced activity; normal equilibrium, opercular rate, and muscle tone	Wet weighing
2	Light anesthesia	No activity; loss of equilibrium; decreased opercular rate and muscle tone; reactive to reflex responses (e.g. tail pinch)	Close visual inspection/health checks; external non-invasive tags; gill or scale scrape
3	Surgical anesthesia	No activity or reflex response; loss of equilibrium; shallow opercular rate; decreased heart rate and muscle tone	Invasive tags; vaccination or other injection; blood sampling; gill biopsy; surgery, fin clip
	Unintentional overdose	Opercular and heart rates stop; no muscle tone; death imminent without life support.	n/a

Table 3.3 Stages of Recovery

Stage	Description
1	Body immobilized but opercular movements just starting
2	Regular opercular movements and body movements beginning
3	Equilibrium regained and preanesthetic appearance

REQUIREMENTS

- **Procedures requiring sedation or anesthesia include injectable vaccination, a scale scrape, fin clipping, tagging, and any other procedure as directed by the farm veterinarian.**
- **Sedatives/anesthetics must be selected and used in consultation with the farm veterinarian.**
- **The use of carbon dioxide is not acceptable.**
- **Depth of sedation or anesthesia must be appropriate for the procedure as outlined in Table 3.2.**
- **Prompt corrective action must be taken if injuries or gasping occur or water quality visibly deteriorates (e.g. debris, stable foam, mucus) during sedation/anesthesia.**
- **If freshwater is used during sedation/anesthesia, it must have a neutral pH or be buffered to a neutral pH.**

RECOMMENDED PRACTICES

a. develop and implement, in consultation with the farm veterinarian, procedure-specific protocols for sedating/anesthetizing fish including
   - duration of feed withdrawal
   - dosage at different life stages and water temperatures
   - behavioural responses to monitor (and frequency of monitoring)
   - water quality parameters to monitor (and frequency of monitoring and water changes)
   - criteria for discontinuing treatment (and guidance on how to do so)
b. confirm appropriate dosage (which can vary according to many factors) by first testing a recommended dose on a single fish or small group of fish
c. use a separate container for recovery
d. consider, in consultation with the farm veterinarian, the use of recovery aids (e.g. salt) particularly if issues during recovery occur
e. revise farm protocols if an unintentional overdose occurs

3.3 Crowding Procedure

With attentive management, stressors associated with the crowding procedure (e.g. reduced oxygen, increased swimming activity) can be minimized (26). When crowding in net pens, deep, narrow crowd nets are generally preferred (compared to shallow crowd nets) as they maintain normal light intensity, permit greater freedom of movement, and reduce the risk of injury (36). The surface water should be as calm as possible with few fish breaking the water's surface and no vigorous activity should be observed (37).

REQUIREMENTS

- **Crowding must be accomplished gradually (i.e. no sudden or rapid decrease in the available space).**
- **The seine or screen must be promptly loosened if crowding behaviour progresses from a score of 3 to 4. Refer to *Appendix F – Assessing Fish Behaviour during the Crowding Procedure*.**
- **Protocols outlining when crowding will be delayed due to poor health status (e.g. gill disease) or poor water quality conditions (e.g. low oxygen, plankton bloom) must be developed and followed.**

RECOMMENDED PRACTICES

a. develop and implement a written standard operating procedure for crowding
b. use deep, narrow crowd nets (36)

c. situate crowd pens such that fish can swim against the tide towards the inlet pipe and preferably into a shaded area (to take advantage of natural fish behaviour) (36)
d. monitor water quality throughout the crowding procedure and avoid any sudden changes in oxygen concentration
e. loosen crowd nets upon seeing any increase in vigorous activity and allow the crowd to calm before tightening
f. monitor fish and water (e.g. for scales) after crowding and refine protocols if injuries occur or return of appetite is delayed (14)

3.4 Grading

Grading is an important part of husbandry as it prevents excessive size variation and competition and promotes uniform smoltification or fingerling size (38). However, the grading process is stressful for fish and necessitates withdrawal of feed. The health status of fish as well as water temperature and other environmental conditions need to be evaluated prior to grading.

The need for grading can be reduced by:

- using equipment that helps yield uniform fish size from first feeding (e.g. automated egg quality machines)
- having a plan for biodensities in all production stages or rearing units
- ensuring optimal feeding strategies, particularly feed distribution and ration size (refer to *Section 4 – Feeding Management*)
- employing lighting regimens that minimize the risk of fish maturation (refer to *Section 2.4 – Lighting*)

There are important welfare benefits to withdrawing feed prior to grading (e.g. reduced injury and mortality) (38). Duration of feed withdrawal depends on many factors, including the nature of handling and associated procedures, water quality, and health status. Refer to Sections *4.3.3 – Feed Withdrawal*.

REQUIREMENTS

- **Protocols outlining when grading will be delayed due to poor health status (e.g. gill disease) or poor water quality conditions (e.g. low oxygen, plankton bloom) must be developed and followed.**

RECOMMENDED PRACTICES

a. develop and implement a written standard operating procedure for grading
b. avoid grading during periods of low- or high-water temperatures, whenever possible (39)

c. perform a health check (especially gill health) prior to routine/planned grading
d. monitor water quality throughout the grading procedure
e. monitor fish and water (e.g. for scales) after grading and refine protocols if signs of injury are noted or there is a delay in return of appetite (14)

3.5 Transfer/Ponding

Optimizing pre- and post-transfer conditions increases the likelihood of successful transfer and provides fish with the best start at grow out. The correct timing for transfer is particularly important for later growth and survival. Many diseases develop in the months following transfer, and these may be directly associated with the stress fish are exposed to in the pre- and post-transfer period – research shows that repeated stress impairs fish health and their coping ability (14).

Signs that fish are not thriving after transfer (whether into salt or freshwater) include: (14)

- weight loss or poor condition factor (<0.9)
- skin darkening and scale loss
- slow or stationary swimming (especially at the surface or corners/sides of the rearing unit)
- poor or no response to feeding.

Refer also to *Section 7 – Transportation*.

REQUIREMENTS

- **The group of fish to be transferred to grow out must be assessed as healthy, vigorous, and fit for transfer.**
- **Fish that are moribund, malformed, severely injured, or in poor body condition must be removed from the group of fish to be transferred as much as is reasonably possible.**
- **Fish condition and performance must be monitored in the early post-transfer period.**

RECOMMENDED PRACTICES

a. grade fish prior to transfer to minimize size variation in the group and ensure optimal feeding management after transfer (refer to *Section 3.5 – Grading*)
b. minimize the pre- and post-transfer water temperature and lighting differences (refer to *Section 2.4 – Lighting*)
c. establish benchmarks for fish condition after transfer (e.g. mortality, return to appetite, failure to thrive) that, if exceeded, will trigger changes to transfer sizes/weights in future groups

d. after transfer, continue to remove fish that are moribund, malformed, severely injured, or in poor body condition as these fish are vulnerable to disease and may become a source of pathogens and parasites affecting other fish

3.5.1 Transfer to Saltwater

Fish that are fully adapted when transferred to full strength saltwater have few osmoregulatory problems and better growth performance after transfer (40). Stage of adaptation may be assessed visually (see Table 3.4 below) or through laboratory testing. Tests include checking for increasing sodium, potassium and ATPase activity in the gill tissue, or assessing sodium and chloride levels in the blood after exposure to full strength saltwater for 24 hours.

In salmon production, temperature control can optimize growth rate but can raise welfare concerns around the completion of smolting and duration of the smolt window and growout to 4 kg (16). For smolting, 10°C is safe and >15°C poses significant welfare risks if the fish are to be transferred to sea pens (16). For growout to ≥4 kg in RAS, 14–17°C appears to be safe (16).

Table 3.4 – Visually Assessing Smoltification Stages in Salmon

Smolt Score	Fish Appearance
1	Parr marks clear, light coloured back, flanks green, belly yellow, no silvering
2	Parr marks fading, back and fins light, flanks starting to silver, belly yellow
3	Parr marks faint, back and fins darkening, flanks silver, belly whitening
4	Parr marks very faint, dark back, yellow only around fin bases and gill cover, flanks silver.
5	Parr marks gone, back dark, dark margin to fin edges, flanks silver, belly white, silver dominant.

Source: RSPCA welfare standards for Farmed Atlantic Salmon, p.33, 2018 (as amended from the scoring system of C. Findlay of the Fish Vet Group, Inverness). Used with kind permission of the RSPCA.

REQUIREMENTS

- **The group of fish in freshwater must not be transported to saltwater until they have adapted to saltwater.**

RECOMMENDED PRACTICES

a. use multiple criteria to assess smoltification status, including swimming pattern, shape, visual assessment, and laboratory tests
b. frequently monitor the degree of adaptation for several weeks prior to the anticipated transfer date so that the optimal time for transfer can be identified

c. gradually adapt fish to the photoperiod and temperatures they will experience after transfer to reduce stress and help ensure complete adaptation (14)
d. avoid high water temperatures (e.g. >15°C for Atlantic salmon) during the smoltification process (16)
e. ensure daytime light intensity at the level of the fish is greater than 10 lux during the smoltification process to avoid deformities in developing fish

3.6 Equipment for Transferring, Handling, and Grading Fish

Selecting appropriate equipment can significantly reduce the occurrence and severity of injuries. Equipment design, material, maintenance, and correct use are all important factors.

Transferring fish by pumping them in pipes where they are not removed from water is less aversive and damaging (41). Fin damage is less severe when fish are moved in knotless nets (42).

REQUIREMENTS

- **Equipment must be free from protrusions and sharp edges and must be designed, maintained, and operated to minimize stress and the risk of injury.**
- **Equipment used to transfer fish must be suitable to the size of fish and must be designed and maintained to prevent escapes.**
- **The mesh size of hand or crowd nets must be suitable for the size of fish to prevent escape, entanglement, entrapment, and injury.**

RECOMMENDED PRACTICES

a. ensure all manufacturer's instructions are followed
b. use equipment that permits fish to stay in water when being moved or transferred
c. minimize the time fish are kept in pumps
d. use vacuum pumps instead of turbine pumps
e. ensure pump speed enables fish to swim in the current (never swimming stationary creating a risk of exhaustion)
f. promptly reduce pump speed if any fish flip during pumping
g. if using turbine pumps, ensure intermediate pump velocities are not exceeded (28)
h. ensure minimal bends and joints in pumps and pipes
i. use knotless or rubber nets when handling or crowding fish

4. Feeding Management

Good feeding management, particularly ensuring intake of a nutritionally balanced diet, is essential to the growth, physiological functioning, and health of salmonids. As cold-blooded species, salmonids do not need to maintain a constant body temperature. This means that periods of feed deprivation, whether from a natural loss of appetite or management strategy, do not necessarily result in loss of body condition, especially at low temperatures, provided that fish have sufficient stored energy in the form of body fat and muscle mass (38).

4.1 Quality and Safety of Feeds

Feed for salmonids is a perishable item, especially when bags are opened, and the quality and safety will change if feed is exposed to air, adverse conditions, or prolonged storage time. Protection from pests is essential to protect the integrity of the bags. Vitamins, proteins, pigments, and lipids are particularly heat-sensitive and can be denatured by high storage temperatures (43). High moisture in feed storage areas stimulates mold growth and feed decomposition (43). The freshness of feed (time in storage) can affect the quality of feed, including its vitamin and antioxidant content.

Pellets should be hard enough to resist abrasion during handling and shipping but soft enough to ensure nutrient availability when consumed (i.e. hold together in water for 4–5 minutes and fall apart within 12–15 minutes) (44). Pelleted feeds should also be stored, handled, and delivered in ways that avoid breakage of the pellets into fines, which will not be consumed by fish and can adversely affect water quality and fish health.

REQUIREMENTS

- **Stored feed must be protected from high temperatures, direct sunlight, pests, and moisture.**
- **Prior to feeding, feed must be visually assessed to confirm it is free from mold.**

RECOMMENDED PRACTICES

a. store feed in areas that are dark, and temperature and humidity controlled
b. store feed in dedicated, secure areas that prevent access by pests
c. incorporate pest control and monitoring strategies in and around feed storage areas (e.g. keep the area around feed storage well-trimmed and tidy)
d. purchase feed in quantities that ensure use prior to the manufacturer's best before date
e. avoid excessive handling of feed bags and feed
f. limit stacking of bagged feed on top of each other

g. maintain a feed sampling program to verify feed quality (e.g. breakage, dust, mold, excess oil)
h. relay any concerns about feed quality to the supplier upon receipt so that prompt improvements can be made (e.g. excessive fines, incorrect or variable pellet size, deviations in fat, protein, and pigment, and floating requirements)
i. ensure all feed is properly labelled
j. ensure feed storage containers are well maintained (e.g. lids close properly, no cracks in the containers) and that the containers are cleaned and disinfected between lots of feed

4.2 Nutritional Needs of Salmonids

Salmonids are carnivores and require a diet high in fat and animal protein. Provision of a balanced, complete diet is essential for preventing nutritional diseases in fish. Feeding a complete diet generally supplies the ingredients (protein, carbohydrates, fats, vitamins, and minerals) necessary for the optimal growth and health of the fish. Some minerals, if present in the water, can be supplied from water (by diffusion across the gill membrane) rather than through feed.

Nutrient requirements vary according to water temperature as well as fish age, size, species, and activity level (44).

Feeding appropriately sized pellets promotes efficient feeding in fish. Generally, pellets that are 20–30% of the size of the fish's mouth gape are suitable (43).

REQUIREMENTS

- **Fish must receive feed that meets their nutrient requirements to maintain good health and meet physiological demands.**
- **Salmonids must be fed pellets that are appropriately sized for their life stage based on manufacturer's standards or the recommendations of a nutritionist.**

RECOMMENDED PRACTICES

a. develop a written feed program for each life stage in consultation with a nutritionist or other qualified specialist

4.3 Feeding Strategies

Factors such as light, temperature, water velocity, social interactions, predators, and disturbance by humans influence feeding behaviour in salmonids. Fish may go off-feed due to

- disease
- water quality deterioration

- poor feed quality
- perceived risk of predation
- maturation
- changes in photoperiod or temperature

Monitoring feeding response and fed amounts will help confirm feed acceptance and detect changes in appetite.

Overfeeding results in feed wastage and deterioration in water quality and can strain filtration systems in re-circulating aquaculture systems or result in benthic impacts. Salmonids may also overeat to the point of permanent gastric distension and, especially in warm temperatures, metabolic stress. Underfeeding is associated with competition, aggression, and inadequate feed intake by some fish resulting in high variation in fish size and the need for more grading (45).

Strategies to ensure good feed access include:

- feeding in a consistent dispersal pattern (46)
- ensuring maximum dispersal of pellets
- preventing dominant fish from defending the feed source
- increasing the delivery rate of pellets (45)
- feeding to satiation (45)
- optimizing stocking density (densities that are too high or low are associated with reduced overall feed availability or intake, territorial behaviour, and injuries) (26)
- grading fish to reduce size variation

Feeding Schedule

Because fry and fingerlings grow rapidly, they can be at greater risk of nutritional disorders (e.g. spinal defects, eye problems, excessive size variation). To mitigate this, they are fed frequently or even continuously (refer also to *Section 4.3.1*). Closer to harvest, a feeding frequency of 1 or 2 times per day ensures good feed access.

The predictability of feed delivery can also influence welfare in some salmonids. If accustomed to a specific feeding time, short-term unpredictability in feed delivery has been associated with increased stress, aggression, and dorsal fin damage (47).

REQUIREMENTS

- **If fish go off feed or there is an unexplained decrease in feed intake, steps must be taken to determine the cause(s) and correct the issue(s).**

- **Feed must be provided in ways that reduce the risk of competition and prevent excessive weight variation within a group, and it must be delivered in a predictable manner in accordance with environment conditions.**
- **Body size and overall condition must be regularly assessed to confirm successful feeding strategies.**

RECOMMENDED PRACTICES

a. consult with the farm's veterinarian on relationships between feeding management and health and regularly update the health plan to minimize dietary health and welfare issues (Refer to *Section 5 – Health Management*)
b. monitor appetite and feeding behaviour at each feeding and adjust the ration in response to changes in appetite and environmental conditions
c. ensure dietary changes (to feed form, quantity, or nutritional content) are gradual
d. sample fish weights routinely and before making feed size changes

4.3.1 Additional Strategies for First Feeding

First feeding is a critically important stage – attentive monitoring can help avoid significant health and welfare issues. Historically, first feeding was recommended when 90% of the group was at swim-up stage; however, current best practice is to initiate feeding when 40–50% of the group is at swim up stage. Exact timing depends on many factors including the type of equipment at the hatchery, temperature, species, and overall alevin management.

REQUIREMENTS

- **Fry must be monitored frequently every day to achieve the correct timing of first feeding.**
- **Once feeding is initiated, fry must be monitored frequently every day to ensure success of first feeding.**
- **Uneaten feed must be promptly removed to maintain good water quality and avoid a buildup of waste.**

RECOMMENDED PRACTICES

a. initiate first feeding when 40–50% of the group is at the swim-up stage
b. offer feed to fry continuously or several (e.g. up to 5) times a day (44)
c. monitor fry during first feeding every time feed is offered or at least 3 times a day if fed continuously
d. remove uneaten feed and clean the rearing unit routinely to maintain good water quality taking care to avoid injuring fry in this delicate life stage

4.3.2 Additional Strategies for Broodfish

In general, diet formulations for broodfish may contain different levels of fat and protein relative to grower diets, with increased levels of certain vitamins and minerals such as ascorbic acid, vitamin E, manganese, iron, zinc, and copper. Carotenoids such as astaxanthin can also be important for producing healthy offspring (48).

Feeding strategies for broodfish differ from those of production fish, particularly as they begin to mature. Broodfish tend to be fed at a lower ration than production fish – feeding of broodfish is typically stopped several weeks prior to final maturation in response to the slow or lack of appetite shown by the fish; this is a behaviour shown naturally by wild salmonids as they direct stored energy reserves to gamete development and spawning.

If broodfish will be kept for repeat spawning, care should be taken to ensure the fish are encouraged back onto feed again so that they can replenish nutrient resources prior to their next spawn. Repeat spawning success is dependent on the condition of the fish (49).

RECOMMENDED PRACTICES

a. consider the use of specially formulated diets to meet the nutritional requirements of broodfish prior to maturation
b. feed broodfish a lower ration than production fish (typically no higher than 1% of body weight per day)
c. encourage repeat spawners to eat as soon as possible after spawning; frequent feedings may help to initiate their appetite again

4.3.3 Feed Withdrawal

There are important welfare benefits (e.g. reduced injury and mortality, reduced fouling of holding water) to withdrawing feed prior to grading, vaccination, transfer, and other husbandry practices (38). Gut evacuation rate is mainly a function of temperature and body size, but temperature appears to be dominant (Table 4.1) (38). Smaller fish have higher energy demands per unit body mass and feed withdrawal may be particularly detrimental if too long relative to the physiological condition of the fish.

In net pens, withdrawing feed can help prevent high mortality during algae blooms, extreme temperature conditions (warm, cold, or ice cover), low oxygen events, and prior to or after a significant storm (38). During an algal bloom, the algae are typically concentrated close to the surface where the photosynthesis rate is highest (38). Salmonids normally remain in the safer, deeper water of the pen, but are attracted to the surface if feed is offered, with possible fatal consequences during these environmental conditions (38).

All feed withdrawal decisions, but especially those related to extended periods of withdrawal, should include consideration of the welfare risks and benefits as well as alternative strategies. For fish approaching market size, the most appropriate strategy in some cases may be to harvest fish early as a means of avoiding a potential long-term withdrawal period.

Table 4.1 – Gut evacuation rate of Atlantic salmon and trout fed a variety of meals*(38)

Species	Body weight (g)	Temperature (°C)	Time (hours)	Degree days (°D)
Atlantic salmon	5600	4	168	28.0
	695	7.1	48	14.2
	150-200	9	30	11.3
	900–1450	13.4	24	13.4
Brown trout	90–300	5.2	42	9.1
	90–300	9.8	27	11.0
	90–300	15	15	9.4
Rainbow trout	142	10	28	11.7
	91	15	24	15.0
	140–145	18	14	10.5

*****Evacuation rates generally range from about 48 hours at 5-7°C to about 15 hours at 15-18°C relatively independent of species and body size. Degree days for gut evacuation range from 9.1-15°D, the exception being 28°D.

REQUIREMENTS

- **Fish must be fasted prior to husbandry procedures to achieve as much gut clearance as possible and promote optimal water quality and minimize fish stress during procedures, taking into consideration life stage, the number and nature of procedure(s), and the environmental conditions.**
- **The duration of feed withdrawal must only exceed the period required for gut evacuation if required to safeguard fish health and welfare under veterinary recommendation as outlined in the health management plan. Refer to *Section 5.1 – Health Management Plans*.**
- **If a group of fish does not have adequate fat reserves to undergo an extended period of fasting, strategies other than feed withdrawal must be taken to safeguard fish health and welfare.**
- **When reintroducing feed, the quantity fed must match intake and minimize feed waste and associated water quality issues, and corrective action must be taken if bloat, mortality, or abnormal behaviours occur.**

RECOMMENDED PRACTICES

a. outline acceptable feed withdrawal times in each routine procedure necessitating withdrawal and keep records to ensure that handling begins when gut evacuation has been achieved
b. increase the frequency of monitoring fish after feed reintroduction
c. identify other sites for net pens if feed withdrawals as a result of algae blooms, superchill risk, or periods of high water temperatures are frequent

4.4 Feeding Equipment

There are welfare advantages and disadvantages to all feed delivery systems (i.e. hand feeding, mechanical feeding devices, on-demand feeders) (45). Criteria for selecting a feeding system that promotes fish health and welfare include:

- ease of cleaning and disinfection
- ability to control the timing and amount of feed given
- dependability and ease of maintenance
- dispersal pattern of feed pellets
- potential for feed wastage and associated water quality impacts

The safety of feeds can be affected by how often feed delivery systems are cleaned.

REQUIREMENTS

- **Feed equipment must be checked daily to confirm it is in good working order, and defective systems must be attended to without delay.**

RECOMMENDED PRACTICES

a. select and locate feeding equipment to minimize the risk of contamination or fouling by wildlife, including birds
b. clean feeding equipment at least once per production cycle. If excess oil, dust, or breakage is detected during quality testing of feed, increase the frequency of feed equipment cleaning

5. Health Management

5.1 Health Management Plans

Health plans contribute to fish health by outlining management and husbandry procedures that reduce disease occurrence and maintain an environment that promotes fish health. Implementing procedures that optimize fish health and minimize infectious and non-infectious diseases will have positive impacts on fish welfare and the productivity of the hatchery/nursery or farm (50).

Aquatic veterinarians play a key role in helping attain the health objectives of the hatchery/nursery or farm. Having a valid, ongoing veterinarian-client-patient relationship (VCPR) helps ensure that the veterinarian will be familiar with your management practices to prevent and respond to health issues, and it is a prerequisite for obtaining some classes of medications. The VCPR also facilitates collaborative decision-making between the producer and veterinarian.

Vaccinations, which are typically administered in the hatchery phase, are an important disease prevention strategy. However, multiple factors influence vaccine efficacy and good overall health management practices are still important for vaccinated fish.

REQUIREMENTS

- **A written health management plan must be developed, implemented, and kept up to date.**
- **A valid, working relationship with a veterinarian (VCPR) must be established for the prevention, diagnosis, care, and treatment of disease.**

RECOMMENDED PRACTICES

a. review the health plan at least annually or whenever there is a disease outbreak or significant change to the rearing environment or management practices potentially impacting fish health
b. strive to continuously improve fish health by taking the following steps in response to any disease
    - obtain a veterinary diagnosis and provide timely treatment (where appropriate)
    - characterize the outbreak by reviewing health and other records (e.g. date of onset, affected lifestages and rearing units)
    - investigate the risk factors (biosecurity, nutrition, management, rearing environment)
    - develop a manageable action plan to prevent new cases
    - communicate the action plan to relevant personnel and monitor implementation

- evaluate the effectiveness of the action plan and refine if needed

5.2 Disease Prevention

5.2.1 Biosecurity

Biosecurity is based on the principles of keeping disease out of the aquatic environment (exclusion) and preventing disease from spreading within the hatchery/nursery or farm (management) and to other sites (containment). This can be done through the control of people, equipment and conveyances, water, animals, feed, and other materials.

Tools to support biosecurity planning are provided in *Appendix K – Resources for Further Information*.

REQUIREMENTS

- **A written biosecurity protocol must be developed, implemented, and kept up to date.**

RECOMMENDED PRACTICES

a. review the biosecurity protocol at least annually or whenever there is a disease outbreak or significant change to disease risk
b. post biosecurity signage throughout the hatchery/nursery or farm to ensure personnel and visitors are aware of, and follow, biosecurity protocols
c. before placement, ensure fish are healthy and low risk for introducing a significant pathogen
d. source eggs and fish from suppliers that have tested for diseases or pathogens of concern and that document and report what they test
e. ensure workflow and handling is from the youngest to the oldest fish and from the healthiest to the least healthy fish, or dedicate staff to specific life stages/groups
f. ensure biosecure storage and disposal of mortalities

5.2.2 Cleaning and Disinfection

Effective strategies for cleaning and disinfecting tools, equipment, and rearing units help minimize disease. Specific strategies will vary but generally include some combination of cleaning and disinfection.

REQUIREMENTS

- **Incubators must be cleaned and disinfected between batches of eggs.**
- **A written protocol for cleaning and disinfection must be developed and followed.**

RECOMMENDED PRACTICES

a. select tools/equipment made of materials conducive to thorough cleaning and disinfection (mainly, non-porous) (51)
b. store and use disinfectants in accordance with the manufacturer's directions to ensure efficacy and safety
c. dedicate equipment to a specific site or fish population rather than moving it between systems, particularly hard-to-disinfect items (e.g. dive and harvest equipment, nets or any fibrous tools/equipment) (51)
d. dispose of wastes associated with cleaning in a biosecure manner as they may contain pathogens that have the potential to spread infection if not controlled (51)
e. remove any loose equipment (from boats or tanks) so that they can be cleaned and disinfected separately (51)
f. ensure cleaned and disinfected tools/equipment are dried prior to being stored (moisture may enhance survival of any remaining pathogens) (51)
g. clean and disinfect rearing units between groups

5.2.3 Fallowing and Quarantine

Fallowing, quarantine, and year-class separation help prevent disease transmission between groups. Quarantine of new fish is particularly important when their health status is in doubt and in recirculating aquaculture systems given the difficulty in eradicating disease, once present, in these systems (remedial treatments may impact the functioning of the biofilter) (52). Fallowing procedures should be based on an evaluation of anticipated benefits, site and area level risk factors, and disease history (51).

RECOMMENDED PRACTICES

a. review the potential need for fallowing and other separation strategies with a veterinarian based on area- and site-specific factors (e.g. overall system design and management, equipment, capacity for effective disinfection, pathogens present)
b. quarantine fish of unknown health status, prior to introducing them
c. where possible, stock fish in an all-in/all-out method (at site and area levels)
d. use single year-class stocking
e. fallow sites between production groups

5.2.4 Pest and Predator Control

Pests and predators can transmit diseases and, given the difficulty of fully eliminating rodents, prevention should be the primary objective. Predators (e.g. mink, seals) may also stress fish and cause injury.

Control measures vary with the type and degree of pest and predator pressure and may include physical barriers, site selection, deterrence, and secure storage of anything that may attract pests and predators (e.g. mortalities, feed).

REQUIREMENTS

- **To safeguard fish health and welfare, strategies for pest and predator control must be developed and followed.**
- **Netting and screens must be regularly checked for holes and maintained in good condition.**

RECOMMENDED PRACTICES

a. eliminate or reduce the number of places pests and predators can use for shelter or nesting (e.g. heavy vegetation around buildings)
b. store feed securely and promptly clean up any spilled feed
c. remove mortalities daily and ensure secure storage

5.3 Monitoring Fish Health

Regular monitoring of fish facilitates early identification of health problems. Assessment of group behaviour is an important indicator of fish stress and health status (53). Some behaviour modifications may be associated with pathogens, parasites, or pollutants (e.g. flashing on the water surface, decreased activity, lethargy) (53). Use of cameras can assist in observing fish throughout the water column with minimal disruption (14).

Include the following in routine assessments of fish health and welfare: (14, 53)

- fish appearance (size, body condition, skin, fin, eye and gill integrity and colour)
- departure from normal schooling behaviour
- loss of equilibrium, slow swimming, or unusual vertical position
- unstructured swimming near the bottom of the rearing unit
- increased respiration or problems with buoyancy

- change in feed intake or feeding behaviour
- presence of moribund fish

Record keeping is important for monitoring changes in fish health status. Without accurate and complete records, the incidence of disease and mortality is often underestimated.

Resources to support fish health and welfare monitoring are included in the Appendix, including:

- *Appendix E – Welfare Indicators*
- *Appendix G – Scoring Fish Welfare Indicators*
- *Appendix H – Troubleshooting Injuries*

REQUIREMENTS

- **Personnel must be knowledgeable in normal fish behaviour and signs of injury and disease.**
- **Fish must be checked daily for general health except during extreme environmental conditions where assessment may compromise their welfare.**
- **Personnel must investigate if there is an increase in the expected daily mortality rate or a significant change in morbidity and must take corrective action as outlined in the health plan. Refer to *Section 5.1 – Health Management Plans*.**

RECOMMENDED PRACTICES

a. establish a system to identify groups of fish that should be monitored more frequently due to injury, illness, elevated mortality, or recent handling or other stressor
b. increase the frequency of monitoring during high risk conditions (e.g. prior to transfer from freshwater to saltwater, deliveries from a new site)
c. educate staff on signs of disease that necessitate veterinarian involvement
d. remove mortalities frequently as part of routine monitoring (ideally daily depending on any restrictions due to water quality issues)
e. keep complete and accurate morbidity and mortality records, including life stage and classification of cause (e.g. predation, type of disease)
f. conduct regular observations or testing for parasites and pathogens of concern to the site and population of fish
g. establish a baseline for expected mortality and morbidity rates, growth rates and acceptable water quality data; monitor for changes in trends; and investigate any deviation from expected rates (*Appendix E – Welfare Indicators* provides a sample approach and suggested benchmarks)
h. aim to achieve health and welfare outcomes in alignment with the green column of *Appendix E – Welfare Indicators*

5.4 Skin and Gill Health

The skin serves as an important first barrier to infections (39). Even a small injury can be a route for infection, and larger wounds and ulcers may compromise osmoregulation (28, 39). The impacts of skin injuries depend not only on the severity and frequency of the injury, but also the potential pathogens that are present in the rearing environment (28, 39).

Risk factors for skin injuries include: (39)

- rearing units whose texture or fittings cause abrasions
- low- or high-water temperatures at transfer
- use of untreated seawater in land-based smolt production
- injuries during lice treatment or other handling events
- water quality issues (e.g. turbidity)
- predators

Gill health can be impaired due to bacterial or viral infections, parasitic infestations, or poor water quality, including zooplankton, phytoplankton, jellyfish, toxins, and debris (39). Reduced gill function negatively impacts the fish's ability to exchange gases and excrete waste products and may make fish more susceptible to stressful events (39).

Fish with gill disease respire more rapidly and display a rapid "clamping" of the gill covers (54). Affected fish may show little interest in feed and show diminished response to other stimuli (54).

RECOMMENDED PRACTICES

a. use *Appendix H – Troubleshooting Injuries* to ensure effective actions are taken to reduce the occurrence of injuries
b. ensure optimal water temperatures at transfer (39)
c. avoid the use of untreated surface water in land-based production
d. avoid the use of untreated seawater in land-based smolt production (39)
e. ensure safe incoming water into freshwater production systems (e.g. disinfect/decontaminate as appropriate based on the water source)

Specific strategies to address gill disease:

f. take steps to address gill disease promptly after it is detected
g. improve water quality wherever possible (e.g. oxygen, carbon dioxide, suspended solids)
h. reduce feed allowance or spread the daily ration into numerous small meals (54)
i. maintain strict biosecurity and hygiene practices (54) (refer to sections 5.2.1 and 5.2.2)
j. remove dead or moribund fish as soon as possible to limit transmission of gill disease (54)
k. treat (when necessary) under veterinary advice

5.5 Sea Lice

The focus of this section is on sea lice, but the same principles may apply when dealing with freshwater lice. The marine species *Lepeophthierus salmonis* is the primary concern for Canadian aquaculture, but several species from genus *Caligus* also infect farmed salmonids. The mobile adult stage of sea lice causes the most damage by grazing on skin tissue. Heavy sea lice infestation can result in skin lesions, notably around the head, behind the dorsal fin and in the perianal region, which may increase the susceptibility of fish to pathogens (55). Jumping and rolling behaviour increases markedly during the initial stages of sea lice infection (14).

Integrated Pest Management Plans

Sea lice management requires an integrated approach that focuses on prevention and best husbandry practices to minimize the need for treatment. Good practices will also reduce the time fish spend at sea and facilitate effective treatments by ensuring that fish are able to receive in-feed treatments or tolerate the additional handling associated with baths or physical removal. An integrated pest management plan includes good husbandry practices, monitoring, record keeping, setting action levels, proper selection and use of both chemical and non-chemical controls, and resistance monitoring. If management fails and lice levels cannot be controlled, fish may need to be harvested early or euthanized.

Treatments and Controls

Several therapies are used to control sea lice. Chemical controls are safe and effective when used according to the manufacturer's instructions and under veterinary supervision, but consideration should be given to lice sensitivity, efficacy at different life stages, water temperature, required withdrawal times, and strategic rotational use to prevent resistance development. There may be containment requirements necessitating the use of full enclosure tarpaulins or well boats to administer bath treatments.

As lice have developed resistance to many products, non-chemical control strategies such as high-water temperatures, low salinity, physical removal, cleaner fish, and cage barriers have been developed. Non-chemical controls that reduce or eliminate initial lice infections include deep nets, deep lights/deep feeding, skirts and semi-closed containment systems that draw water from depth (55). As some of these methods restrict both lice and water flow, environmental conditions and oxygen levels need to be appropriate for their use to be safe. Non-chemical controls also include cleaner fish and mechanical removal methods (e.g. Hydrolicer) that physically dislodge lice from fish (55). Both bath treatments and physical lice removal methods require additional handling and crowding that may result in injuries, scale loss, and gill damage (55).

Area-based management has also evolved as a best practice for sea lice control (56). The goal of area-based management for sea lice is to coordinate production practices (e.g. stocking, treating, harvesting, fallowing) between farms to ensure that sea lice are not moving amongst sites, defeating control efforts.

REQUIREMENTS

- **An integrated pest management plan for the control of sea lice must be developed and implemented in consultation with the farm veterinarian.**
- **Personnel involved in sea lice management must be trained in sea lice biology, including how to identify different species and life stages of lice, as well as the signs of lice infection.**
- **Lice levels must be monitored through direct counts and records must be kept on lice numbers, seasonal trends, controls, and results.**
- **Chemical controls must be licensed for use in Canada or obtained as an emergency drug release and used only as directed by the farm veterinarian.**
- **When using bath treatments or physical methods of lice removal, treatment efficacy and fish condition must be assessed throughout, and the treatment must be promptly stopped and corrections made if any injuries, scale loss, or mortalities occur.**

RECOMMENDED PRACTICES

a. include, in the integrated pest management plan, strategies and technologies that prevent lice infection and do not necessitate crowding and handling (e.g. deep lights, deep feeding, semi-closed containment systems) (55)
b. increase the frequency of lice monitoring during high risk periods (e.g. wild fish migration)
c. test the sea lice treatment on one fish or a small group of fish prior to treating a larger number of fish
d. ensure veterinary supervision the first time any physical methods are used
e. monitor fish condition in the days following treatment and refine strategies if signs of stress are noted (e.g. delay in return of appetite, change in feeding response, slow swimming) (14)
f. participate in area-based management initiatives where applicable

5.6 Additional Considerations for Maintaining Healthy Broodfish

Broodfish are often reared over a longer period of time than production fish. Therefore, they may be at higher risk of exposure to pathogens. At freshwater facilities shared by other fish year-classes, biosecurity is particularly vital to prevent the transfer of pathogens from the mature fish to susceptible young fry.

Saprolegnia infections are common in sexually mature salmonids, especially males, and can be serious. During handling events it is important to ensure that no wounds occur on the fish because these will be opportunistic areas for fungal growth. Salt baths and/or supplementation with seawater in the rearing unit can be useful for prevention and treatment (31).

Disease screening procedures may be conducted at the time of spawning to mitigate risk of transmission of pathogens to progeny. Tests to be performed are at the discretion of the veterinarian but may include screening for issues such as bacterial kidney disease or viruses.

REQUIREMENTS

- **Strict disinfection and hygiene procedures must be in place when working with broodfish.**

RECOMMENDED PRACTICES

a. select designated staff and equipment that interact only with broodfish
b. hold mature broodfish at designated facilities or in a designated area of a facility removed from production or hatchery/nursery fish
c. use a separate water supply for broodfish
d. optimize nutrition and minimize stress to control *Saprolegnia* infections
e. conduct disease screening at the time of spawning to minimize the risk of transmission of pathogens
f. use salt baths to prevent and treat fungal infections
g. supplement broodfish holding units with low levels of seawater to mitigate secondary infections (not to exceed 10% saltwater) (31)

6. Euthanasia, Slaughter, and Mass Depopulation

Humane approaches to euthanasia, slaughter, and mass depopulation are important for fish welfare and expected by society and the aquaculture industry alike.

Those who are responsible for performing end of life procedures on fish should be aware that they may be at risk for traumatic stress and should take preventive measures to mitigate this risk (4, 57). Coping mechanisms can vary from person to person. Owners and managers should continue to be vigilant and impress on staff and service providers that the fish that will be killed must continue to be treated in a manner that promotes their welfare until the very end.

Mass depopulation events can have a particularly significant impact on the well-being of everyone involved, including producers, staff, families, and veterinarians. The trauma may be more significant for owners and those who have been directly involved in the day-to-day care of the fish. Where feasible, it can be beneficial to arrange for fish to be depopulated by an external service provider (a team specifically trained in slaughter, as an example).

6.1 Planning and Protocols

Having protocols can improve confidence when euthanizing, slaughtering, or depopulating fish and helps ensure these procedures are carried out in a consistently humane manner.

Include the following in on-farm protocols: (58)

- criteria for when to euthanize
- method(s) (including an alternative method or back-up equipment)
- clear intervention and end-point criteria
- operational procedures (e.g. safety procedures for personnel, maintenance of equipment)
- roles and responsibilities
- discharge of any contaminated water
- carcass disposal and/or end use
- strategies to identify signs of traumatic stress and to support the well-being of personnel
- reporting procedures as required by designated authorities

REQUIREMENTS

- **Fish must be promptly euthanized if they have a condition that compromises their welfare and**
  - **they do not have a reasonable prospect of improvement, or**
  - **are not responding to treatment(s) within an appropriate timeframe, or**
  - **treatment is not a humane option.**
- **A written euthanasia protocol must be developed and implemented with veterinary input.**
- **On farms that slaughter fish, a written slaughter protocol must be developed and implemented with veterinary input.**
- **A written contingency plan for mass depopulation must be developed with veterinary input.**

RECOMMENDED PRACTICES

a. review and update protocols at least annually or whenever there is a significant change to the rearing environment or management practices that impact fish welfare during euthanasia, slaughter, or depopulation

b. use checklists or other documentation to track observations throughout the procedure

Recommendations specific to mass depopulation:

c. do at least one practice drill of the contingency plan well in advance of an emergency to help ensure preparedness

d. designate one person to serve as a team leader through all stages of depopulation to provide oversight, monitor fish welfare, and support staff

e. conduct a planning discussion with personnel to coordinate activities and operational procedures immediately prior to the depopulation event

f. arrange a debrief with personnel after a depopulation event and refine the contingency plan based on feedback

6.2 Methods

Acceptable methods are those that result in rapid, irreversible unconsciousness (insensibility), followed by prompt death (4, 58, 59). For this reason, methods that affect the brain first followed quickly by cardiac and respiratory arrest are preferred (4). When insensibility is not immediate, induction of unconsciousness should be non-aversive or the least aversive possible and should not cause distress or suffering in fish (4, 6, 58). Acceptable methods are listed in *Appendix I*.

The most humane method for the situation should always be chosen. Other important considerations when selecting a specific method include:

- the number of fish involved and their size(s) and life stage(s)
- the emotional comfort of the personnel performing the procedure and any bystanders
- the type of aquaculture system
- the availability of necessary equipment and/or anesthetic drugs
- discharge of any contaminated water
- carcass disposal and/or end use
- specific disease or pathogen present in a population (including its host and environmental survival) (if applicable)

The use of acceptable methods may not be feasible in all depopulation contexts (6). Selection of the most humane option may be constrained by limited carcass disposal or end-use options and/or the nature of the emergency (6). In some cases regulatory authorities may be involved, and the decisions may ultimately reside with these authorities.

Beyond the procedure itself, it is also critically important that prior crowding, transfer, and/or handling be kept to a minimum and carried out in the most humane way possible to reduce distress, fear responses, and suffering (refer to *Section 3 – Husbandry Practices*) (58, 59).

REQUIREMENTS

- **An acceptable method of euthanasia, slaughter, and depopulation must be used. Refer to *Appendix I*.**
- **Methods of euthanasia, slaughter, and depopulation must be quick, cause minimal stress and pain, and result in rapid loss of consciousness followed by death without the fish regaining consciousness.**
- **Effective January 1, 2024, ice slurry slaughter must not be used as the sole means of slaughtering fish. As of this date, ice slurry must only be used as a secondary step to ensure death.**
- **Use of a method not listed as acceptable in Appendix I is only permitted in exceptional emergency circumstances as outlined in a contingency plan developed with veterinary input. Refer to *Section 6.1 – Planning and Protocols*.**
- **Prior to euthanasia, slaughter, or depopulation fish must be handled, crowded, and moved humanely. Refer to *Section 3 – Husbandry Practices*.**

RECOMMENDED PRACTICES

a. test the method on one fish or a small group of fish prior to performing the procedure on a larger number of fish to ensure effectiveness (59)

6.2.1 Training and Equipment

Persons engaged in the handling, stunning, and killing of fish play an important role in their welfare (58). The successful application of any method depends on many factors, particularly the experience, training, sensitivity, and compassion of the individual carrying out the procedure (4). Personnel who have received training have greater confidence and the skills to perform the procedure competently.

Proper storage and maintenance of equipment is essential to ensure the equipment functions effectively (60).

REQUIREMENTS

- **Personnel must be competent in the euthanasia, slaughter and/or depopulation methods used.**
- **Equipment must be used, stored, and maintained according to the manufacturer's instructions to ensure proper functioning.**

RECOMMENDED PRACTICES

a. maintain accurate records of equipment maintenance and training
b. routinely monitor personnel for proficiency during euthanasia, slaughter, and depopulation
c. routinely monitor personnel for signs of emotional distress and offer supports to ensure their ability to carry out the procedures humanely and correctly is not affected (60)

6.2.2 Confirming Insensibility and Death

Multiple indicators should be used to confirm death, including

- loss of movement
- loss of reactivity to any stimulus
- flaccidity
- respiratory arrest (cessation of rhythmic opercular movement)
- loss of eye-roll (the movement of the eye when the fish is rocked from side to side)

A fish's heart can continue to contract after brain death and is not necessarily an indicator of recovery (60).

REQUIREMENTS

- **A repeat procedure (or alternate method) must be promptly performed if signs of recovery are noted.**
- **Fish must be dead before disposal or processing.**

RECOMMENDED PRACTICES

a. establish clear intervention points (e.g. fish are obviously recovering from unconsciousness)
b. establish clear end points (e.g. minimum time after opercular movements stop)
c. use multiple indicators to confirm death

7. Transportation

Fish are transported by road, water, and air. Moving fish underwater in net pens (to another site or for slaughter) is also considered transport. Refer to *Section 3 – Husbandry Practices* for guidance on on-farm movement/transfer of fish.

The federal requirements for animal transport off the farm are covered under the Health of Animals Regulations, Part XII.[1] They are enforced by the Canadian Food Inspection Agency (CFIA) with the assistance of other federal, provincial, and territorial authorities. Some provinces have additional regulations related to fish transportation. Those with responsibilities during any part of the transportation process (i.e. loading, confinement, transporting, or unloading) must be familiar with, and follow, all applicable animal transport requirements.

When moving fish or eyed eggs as cargo within aircraft, the requirements for loading density and container design and construction set out in the *Live Animals Regulations* must be met (1).[2]

7.1 Training and Record Keeping

Transportation of animals is highly specialized and requires suitably trained and knowledgeable personnel. Transporters must be trained in the following areas of fish transportation including: (3)

- normal fish behaviour and signs of stress in fish
- assessing fitness for transportation, including risk factors (refer to *Section 7.2.2 – Assessing Fitness* for *Transportation*)
- appropriate loading densities
- methods for handling, loading/unloading, confinement, and transport
- effective monitoring throughout the transportation process
- the contingency plan (refer to *Section 7.7 – Emergency Preparedness and Response*)

REQUIREMENTS

- **Personnel who load, confine, transport, or unload fish must have the competence to properly carry out the procedures they are responsible for (3).**
- **Transporters must maintain accurate and complete records for each shipment (3).**

[1] The Health of Animals Regulations are accessible through the link below (accessed May 23, 2020) or by doing an Internet search for "Health of animals regulations" www.laws-lois.justice.gc.ca/eng/regulations/c.r.c.,_c._296/page-16.html#docCont

[2] International Air Transport Association. Live Animal Regulations. Available for purchase at: https://www.iata.org/publications/store/pages/live-animals-regulations.aspx.

RECOMMENDED PRACTICES

a. develop and implement a written animal welfare policy outlining the transporter's commitment to responsible care of eggs and fish (see *Appendix A – Sample Fish Welfare Policy*)
b. participate in continuing education activities related to egg and fish transport
c. develop and implement detailed standard operating procedures to facilitate training and ensure consistency in the procedures
d. document training and certifications completed (see *Appendix B – Sample Training Log*)
e. routinely assess compliance to standard operating procedures
f. update standard operating procedures at least annually (or whenever important improvements are made to procedures) and promptly communicate changes to transporters (Appendix C provides a sample form to help track these activities)
g. identify managers or mentors that personnel can approach with their questions/concerns about egg and fish transport

7.2 Preparations for Transportation

7.2.1 Planning and Arranging Transportation

Personnel responsible for arranging transportation need to be aware of how long fish may be in transit (including intermediate stops, if applicable) and the additional services the transporter needs to provide during transit (e.g. water quality monitoring, water exchange, settling fish). When unsure, assume the longest possible journey.

Fish have a sensitive lateral line system, and may exhibit motion sickness if transported in bad weather or poor road/sea conditions (61). Weather forecasts should be assessed when planning a journey to minimize exposure to poor conditions.

Planning also includes consideration of the potential need to acclimatize fish to the next production stage or receiving site (e.g. light, water temperature and salinity changes) (refer to *Section 3.5 Transfer/Ponding*). It is important to avoid exposing fish to sudden changes in light intensity as this may cause fear responses, increased oxygen consumption, injuries, or suffocation. To habituate fish to a change in light intensity, fish need to be gradually exposed to these lighting levels before transport. The time that fish are in transit may be part of the acclimation process for water quality parameters.

Prior feed withdrawal is essential to maintaining good water quality during transportation. *Section 4.3.3 – Feed Withdrawal* provides a table of gut evacuation rates.

REQUIREMENTS

- **Fish on a 24-hour light regimen must be exposed to dark periods over at least 3 days prior to shipping to prevent crowding at the bottom of the container, unless transportation containers permit the entry of ambient light or are artificially lit.**
- **Fish must be fasted for a minimum of 24 hours or 10 degree days (whichever is longer) prior to transport to achieve as much gut clearance as possible and promote optimal water quality during transportation.**
- **At or before the time of loading, producers must communicate the fasting period to transporters to support good water quality management during transport.**
- **Refer also to the Requirements in *Section 4.3.3 – Feed Withdrawal*.**

RECOMMENDED PRACTICES

a. ensure receiving water temperature, oxygen and pH are as close as possible to the parameters in the shipping site (e.g. temperature difference should ideally not exceed +/-4°C, as a guide)
b. schedule transportation such that delays are avoided due to severe weather, road construction, ferry cancellations, as examples
c. select routes with the best possible conditions (e.g. smooth roadways, avoid high seas)
d. ensure the following is discussed and agreed upon with the transporter, prior to transport:
    - number, size range, and weight of fish to be transported
    - current health status of fish to be transported
    - loading densities in containers
    - equipment to monitor and maintain water quality, including at the receiving site
    - water quality parameters (e.g. temperature, oxygen, CO_2, pH)
    - frequency of monitoring water quality and fish and associated record keeping

7.2.2 Assessing Fitness for Transportation

Fish producers care for large numbers of fish, which makes assessment of individual fish difficult. However, producers must take measures to ensure that groups of fish are assessed for fitness prior to loading. Risk factors that must be considered when evaluating a group's fitness for transport include: (3, 62)

- life stage
- current condition of the fish and any recent disease or other stressor
- population mortality rate

- the expected duration of the journey and confinement in the container (including foreseeable delays)
- the foreseeable conditions during transport (e.g. sharp inclines/declines; weather, particularly in well boats); and
- the type and condition of the conveyance, container, and equipment

A group of fish is unfit for transportation due to illness, injury or any condition that indicates that the group cannot be transported without suffering (3). A group of fish is compromised if they have a reduced capacity to withstand transportation due to weakness, illness, injury, or other cause (3). *Appendix J – Transport Decision Tree*, provides guidance on determining fitness for transport.

Special provisions are measures that are intended to prevent suffering, injury or death and include, among others, slow shipping, lower density, and increased monitoring frequency.

REQUIREMENTS

- **In preparation for transport, the group of fish to be transported must be evaluated for fitness and**
  - **fish that are unfit for transport must be euthanized, separated, or transported with special provisions only on the advice of a veterinarian to receive veterinary care**
  - **fish that are compromised must only be transported with special provisions directly to the nearest slaughter facility or grow out environment in the best interest of the fish (i.e. not through an assembly or distribution centre).**
- **Compromised and unfit fish must be removed from the population of fish to be transported as much as is reasonably possible.**
- **Conditions that make a group of fish unfit or compromised are outlined in *Appendix J – Transport Decision Tree*.**
- **Mortalities must be removed prior to loading.**

RECOMMENDED PRACTICES

a. ensure proactive grading and culling throughout production stages to reduce the number of compromised or unfit fish at the time of transportation
b. avoid, as much as possible, any procedures that may affect fitness for transport in the weeks prior to shipping
c. increase health monitoring as transportation nears to ensure early detection of a condition that may warrant early shipping, as appropriate, before fish become compromised
d. consult a veterinarian if in doubt about a group's fitness for transportation and when transporting compromised fish

e. outline, in the health management plan, water quality and fish health criteria for when fish may be transported to a new grow out environment or shipped early to slaughter to safeguard health and welfare (refer to *Section 5.1 – Health Management Plans*)
f. develop, in consultation with a veterinarian, standard protocols for specific conditions that would render a group of fish unfit or compromised

7.2.3 Loading Density

Loading density in containers has a significant impact on water quality throughout the transportation process. Factors to consider when selecting a loading density include duration of transport, water temperature, weather conditions, and the group's fitness and life stage. A high density combined with a long transport duration can cause stress and mortality. At inappropriately high densities, fin erosion and scale loss may occur, and fish may be unable to maintain their preferred position of being horizontal and upright in the water column. As a rule, as the transport time increases (particularly >8 hours), the loading density should be reduced (63).

REQUIREMENTS

- **Loading density must be determined prior to loading, taking into consideration fitness for transport, body size/weight, lifestage, weather conditions, and the duration of transport.**
- **Loading density must minimize fin erosion and scale loss and permit fish to maintain a horizontal position.**
- **Loading density must not exceed 150 kg/m3 (i.e. 15% fish, 85% water).**

RECOMMENDED PRACTICES

a. start with a low loading density (e.g. 40–50 kg/m^3 depending on life stage) increasing from this amount only if good outcomes are consistently achieved and transporters are suitably experienced

7.3 Loading and Unloading Procedures

Skilled, patient, and humane loading improves fish welfare and reduces losses associated with these processes (62). Some research has shown that while fish's stress response can increase with journey duration, loading and unloading may be the more stressful part of the transportation process (62, 64). Injuries incurred during crowding, pumping, or manual loading can compromise a group's ability to handle the stress of transportation potentially making them compromised or unfit.

Eggs require careful handling and transport at all development stages but are particularly susceptible to damage before they reach the eyed stage.

REQUIREMENTS

- **Fish must be loaded/unloaded at a speed and in a manner that minimizes the risk of injury, enables fish to promptly revert to a normal distribution in the water column, and prevents crowding at the bottom of the container or rearing unit.**
- **Eyed eggs must not be allowed to dry out and must have air space in their container.**
- **During unloading, fish in the container must be covered with water and the last fish to be unloaded must be netted out (never swept or dragged).**
- **Refer also to the Requirements in *Section 3.2 – Handling* and *3.6 – Equipment for Transferring, Handling, and Grading Fish*.**

RECOMMENDED PRACTICES

a. complete documentation and permissions prior to loading fish to avoid delays in transit
b. minimize movement of eggs between the fertilization and eyed stages
c. strive to keep the time fish are out of water to <30 seconds (32,33)
d. ensure pump speed enables fish to swim in the current (never swimming stationary creating a risk of exhaustion)
e. promptly reduce pump speed if any fish flip during pumping
f. consider the use of horizontal baffles during transport to minimize sloshing

7.4 Transport Containers

Proper design and operation of transport containers (e.g. wells, tanks, net pens for underwater transport) can reduce many fish stressors (63). Tank/well construction and material play a vital role in maintaining the water temperature within the desired range particularly if the water and air temperature differ significantly (63). Salmonids have been shown to prefer and behave less aggressively in rearing units with dark backgrounds (9), which may also apply to transport containers.

REQUIREMENTS

- **Net pens that are used to transport fish under water must be adequately tensioned and of a weight that prevents distortion and associated crowding, entanglement, or injury.**
- **Containers must prevent fish escapes and water leakage and be free from projections or loose fittings that may injure fish.**
- **Containers must be designed or properly insulated so that any change in water temperature is within the adaptive ability of the fish.**
- **Containers must permit visual inspection of fish (e.g. top latch), clearly indicate the presence of eggs or live fish (on at least 2 sides) and clearly indicate the upright position of the container (3).**
- **Containers loaded with eggs or fish must never be handled in a manner likely to cause suffering, injury, or death.**
- **Containers must be filled with water to a level that minimizes sloshing.**
- **Containers must be cleaned and disinfected after an entire group has been moved.[1]**

[1] Except for one-time use containers and net pens used to transport fish.

RECOMMENDED PRACTICES

a. identify containers with better insulation properties if water temperatures during transportation fluctuate more than +/ - 1.5°C per hour, as a guide

7.5 Road and Water Transportation

7.5.1 Monitoring Water Quality and Fish During Transport

Water is the life support system for fish. While feed withdrawal and oxygenation both help maintain water quality, parameters can deteriorate during transport, particularly during long journeys and where there is little or no opportunity to exchange water (62). Oxygen levels have been shown to decrease significantly during the loading process, so it is important to saturate or supersaturate water with oxygen prior to placing a load of fish into a container (63). Oxygen levels decrease as water temperature increases, so temperature control is also vital during transport.

Waste products from fish (e.g. ammonia, carbon dioxide) and suspended solids tend to increase with journey duration, and these changes are more pronounced with increased loading density (62). Ammonia toxicity is a concern, especially during long hauls (63). The accumulation of ammonia can be minimized by fasting fish prior to transport (see *Section 7.2.1 Planning and Arranging Transport*). Elevated levels of carbon dioxide are also a concern during transport and could result in acidosis and possibly death (63). Heavy aerators and agitators can be used to remove carbon dioxide from the water (63).

During transport, fish must be periodically monitored for any abnormal behaviour. Some examples include:

- laboured breathing or gasping
- fish crowding themselves in a small area of the container
    - crowding at the bottom of the container (a sign of insufficient oxygen)
    - crowding at the top of the container (a sign of high oxygen)
- rushing to the oxygen/aeration/degassing system (and secondary issues)
- darting and flashing

REQUIREMENTS

- **Containers must only be opened as necessary to inspect fish, eggs, or water quality.**
- **Prompt corrective action must be taken if an abrupt change in water quality occurs or fish show abnormal behaviour.**
- **Oxygen levels must be maintained at a minimum of 80% during transport.**
- **Water quality parameters during transport must be similar to the water quality parameters at the source and the destination, unless fish are acclimated before or during transport (e.g. to a different temperature).**
- **If a group of fish becomes compromised or unfit during transport, reasonable measures must be taken as soon as possible to prevent suffering, injury, or death (3). Refer to *Appendix J – Transport Decision Tree*.**

RECOMMENDED PRACTICES

a. install cameras for continuous monitoring of fish
b. use sensors that continuously monitor water quality
c. ensure a visual inspection of water and fish every 1–2 hours if cameras and sensors are not in use
d. ensure lids are removed in a manner that does not cause a fright response in fish
e. install temperature loggers particularly for eggs and fry (to enable monitoring without opening the container)
f. check and calibrate all monitoring equipment prior to each trip
g. use supplementary oxygen or aeration during transport. Ensure a secondary source of oxygen is available in case the first source fails

h. have a procedure in place to maintain conditions within the container of eyed eggs if it needs to be opened (e.g. adding oxygen)
i. avoid abrupt changes in water quality during transport

7.5.2 Use of Additives During Transport

Excessive mucus or foaming may indicate a water quality issue (including an abrupt change in temperature), improper loading, or that fish are stressed due to some other cause. Additives such as anti-foam agents may occasionally be used to mitigate this issue, in addition to several other issues including pH stabilization, and ammonia removal.

Sedation may be used to reduce the stress response during the transportation process. It may also be used to slow the metabolism of fish, thus reducing oxygen uptake and decreasing carbon dioxide and ammonia production, which may allow for higher loading densities to be used (63). Only light sedation should ever be used during transport, to ensure that physiological functions are preserved and to prevent fish from injuring themselves upon induction or recovery (as is possible with deeper sedation or anesthesia). See Stage 1 of *Table 3.2 Stages of Sedation and Anesthesia* for further information. Additives that alter fish actions make it difficult to assess behaviour and well-being during transport, so need to be used with caution.

REQUIREMENTS

- **Additives must only be used according to the manufacturer's instructions or on the advice of a veterinarian.**

7.5.3 Driving and Other Journey Factors

Research in other farm animal species transported by road has shown that driving conditions (e.g. acceleration, braking, cornering) directly impact on the stress and welfare of the animals (65). During transport, fish are at risk of physical damage through the motion of the vehicle or boat associated with driving practices and condition of the road or sea. Weather also significantly influences the amount of physical disturbance fish experience and boat transport in rough waters (strong breeze, wind gusts, high waves) is associated with an increased stress response and post-transportation mortality (62, 64).

Transportation in good conditions may enable fish to recover from the loading process – without this opportunity, fish are exposed to multiple, additive stressors (loading, transport, and unloading) that cumulatively impact their health and overall condition in the weeks following transportation (64).

REQUIREMENTS

- **All lids, outlets, or any other openings must be secured before departure.**
- **Containers must be secured to the conveyance prior to departure.**
- **Hatchery/nursery and farm personnel must minimize the risk of sloshing by ensuring that on-site roads and laneways are free of obstructions and large potholes.**
- **Transporters must drive in a manner that minimizes the risk of sloshing, injury, and uncontrolled movement of fish.**
- **Net pens that are used to transport fish under water must be driven at a speed that prevents distortion and associated crowding, entanglement, or injury.**

7.6 Transfer of Care and Post-Transportation Monitoring

Under the Health of Animals Regulations, the responsibility for the care of fish is transferred from the transporter to the slaughter plant or assembly/distribution centre when the consignee acknowledges receipt of required documentation and when unloading is complete.

After arrival, the duration of time before unloading will depend on water quality but should ideally permit fish to briefly settle prior to being unloaded.

The overall condition of fish, any scale loss, and the time it takes for appetite to return are important indicators of how well fish have coped with transportation procedures. Transport-associated mortality might be the result of one severe stressor or several mild stressors (63). Relevant stressors include handling, confinement, abrupt changes in water quality, and improper acclimation (63).

REQUIREMENTS

- **The consignee must receive documentation on the date and time of arrival, any adverse events that occurred during transport, and the fasting period.**
- **The fasting period can only be continued after unloading if necessary due to water quality issues (e.g. plankton).**
- **Refer also to the Requirements in *Section 4.3.3 – Feed Withdrawal*.**

RECOMMENDED PRACTICES

a. ensure information between the transporter and receiver is exchanged about the time since the last water exchange and/or water quality check

b. track the condition of fish upon arrival (e.g. scale loss) on a site-by-site basis throughout the year and take corrective actions if a deviation from normal at any site is observed
c. implement corrective actions if return to feed intake after transportation exceeds 3 days
d. track mortality associated with transportation (i.e. during transport and in the week following) including cause, if known
e. implement corrective actions if mortality during transportation or unloading exceeds 0.1%
f. implement corrective actions if mortality exceeds 1% in the population after transport
g. provide detailed feedback to the facility of origin and transporters about fish condition after transportation to promote continuous improvement

7.7 Emergency Preparedness and Response

Emergencies or unforeseen issues can arise during the transportation process that impact the welfare of fish being transported (e.g. accident involving the conveyance, equipment failure). Pre-planning will assist transporters to respond in a timely and effective manner and is required under Part XII of the Health of Animals Regulations.

Alternative means of maintaining the life support system include:

- sufficient oxygenation and back-up supply lines and regulators
- connecting a system that has failed to one that is still working
- alternate routes and places along the route where fish can be unloading
- sites along the route where back-up air or oxygen or other essentials are available

A link to a sample contingency plan is given in *Appendix K – Resources for Further Information*.

REQUIREMENTS

- **Transporters must have a contingency plan outlining**
  - **measures to address fish that become unfit or compromised during any part of the transportation process**
  - **measures to address unforeseen delays or other emergencies during transportation that may affect fish welfare, and**
  - **emergency euthanasia or depopulation during transportation.**
- **The contingency plan must be communicated to relevant personnel.**
- **Transporters must have an emergency contact list accessible in the conveyance.**
- **Alternative means of maintaining the life support system of fish must be available and implemented in the event of a mechanical breakdown or other emergency in transport.**

RECOMMENDED PRACTICES

a. update the transportation contingency plan after an emergency incident to promote continual improvement in planning and response strategies
b. have a secondary route (or alternate near-by destination) should the primary route become inaccessible
c. ensure supplementary oxygen or air supply sufficient to last 50–100% longer than the anticipated journey duration

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Appendix A – Sample Fish Welfare Policy

[Your Farm/Company] Employee Animal Care Code of Conduct

Our commitment to our animals

[Our company/farm] is committed to responsible farm animal care and handling. That means animals in our care deserve to be healthy, safe and well cared for.

Our commitment to our customers

Working with animals is important work that we take seriously. We are proud of the work that we do, and we strictly enforce responsible farm animal care and handling among employees and service providers at our facility.

Every person who handles or comes into contact with an animal is required to support our core objective of responsible farm animal care and handling. The demonstration of that support is through the review and signing of this Code of Conduct agreement on a **[quarterly/annual]** basis.

Our commitment to our employees

Your job is valuable and important to our animals, and our business. When you report an incident involving possible mistreatment, illness or injury involving one of our animals, we will take it seriously. We will document your concern. We will follow up to resolve the animal's situation, and/or provide additional training among employees.

Our employees' commitment to us

Every one of our employees is required to handle and treat animals with respect and in accordance with **[farm/company]** policies and rules as well as the federal, provincial and municipal regulations under which we operate.
Any employee who is responsible for, observes or receives any information that alleges an animal on our property or in our care is being mistreated, mishandled or treated or handled in a way that is contrary to our animal care policy/guidelines must report that information to **[NAME OF POINT PERSON]** immediately so that the situation can be corrected**. [PROVIDE CONTACT INFO].**

Failure to adhere to this agreement is cause for dismissal**. [Farm/company]** reserves the right to refer animal-abusers to law enforcement for prosecution.

I __________________________ understand and acknowledge that willful neglect, mishandling or abuse of animals by any [name of company] employee or witnessing it and not reporting it is subject to discipline including immediate termination of employment, and that offenders may also be subject to prosecution under applicable laws.

______________________________ ________________________
Signature of employee Date

Print name: ____

______________________________ ________________________
Signature of employer Date

Name and Title: ____

Important Note: Seek advice from your legal counsel and human resources department if appropriate to ensure any agreement meets relevant labour laws and union contracts.

Used with permission from Farm & Food Care Ontario.
https://www.farmfoodcareon.org/wp-content/uploads/2016/06/Animal-Care-Code-of-Conduct-2016.pdf

Appendix B – Sample Training Log

Date(s)	Topic(s) & Format	Employee Name and/or Signature	Name and/or Signature of Trainer

Appendix C – Sample SOP Review and Training Checklist

SOP Name: ____

Date of last update: ________________________________

Key updates and reason(s) for changes:

____

____

Staff review/training:

<Name>: ____

Date of review/training: _______________________

<Name>: ____

Date of review/training: _______________________

<Name>: ____

Date of review/training: _______________________

SOP Name: ____

Date of last update: ________________________________

Key updates and reason(s) for changes:

____

____

Staff review/training:

<Name>: ____

Date of review/training: _______________________

<Name>: ____

Date of review/training: _______________________

<Name>: ____

Date of review/training: _______________________

Appendix D – Relationship between Biodensity and Welfare Outcomes

The impact of biodensity on fish welfare is dependant on the interaction of several variables, including species, life stage, water quality, feed access and the ability to control the environment within different types of rearing units. In general, the potential for negative welfare is increased with high densities, but as illustrated below, high density does not always result in negative welfare outcomes, nor does low density always result in positive welfare outcomes. With good water quality and attentive husbandry, healthy fish may do well at higher densities. However, the overall condition and behaviour of the fish should serve as the main considerations when assessing welfare in relation to stocking density, and the table below outlines some of the outcomes that need to be considered when selecting an appropriate density.

Welfare Indicator	Fish Type	Life Stage	Rearing Unit	Min (kg/m^3)	Max (kg/m^3)	Outcome
Mortality	Atlantic Salmon	Parr (~70g)	Indoor tanks	21	86	No difference in mortality
	Arctic Charr	Juvenile (~177g)	Tanks	30	150	No difference in mortality
	Rainbow Trout	Fingerlings (~0.21g)	Outdoor flow-through raceways	10 kg/m^2	12.5 kg/m^2	Mortality was reduced in lower density treatments
Fin Erosion	Atlantic Salmon	Post Smolt (~494g)	Recirculating Aquaculture System	10	53	Pectoral fin damage occurring at 53 kg/m^3
	Arctic Charr	Juvenile (~177g)	Tanks	30	150	No caudal or dorsal fin damage, regardless of density
	Rainbow Trout	Juvenile (~113g)	Flow-through tanks	25	120	Fins were less eroded at the lowest density
Aggression	Atlantic Salmon	Adult (~980g)	Tanks	15	35	General rates of aggression between fish did not differ between density treatments, but during feeding, rates increased with decreasing density and levels of disturbance from personnel
	Arctic Charr	Juvenile (~0.85 g)	Tanks	8.7	44	Significantly fewer aggressive interactions at high densities (44 kg/m^3)

Size Variability	Atlantic Salmon	Post Smolt (~494g)	Recirculating Aquaculture System	10	53	Body sizes were the same within low (9 kg/m^3) and high (53 kg/m^3) density treatments
	Arctic Charr	Juvenile (~0.85 g)	Tanks	8.7	44	Body size was more variable at low densities
	Rainbow Trout	Juvenile (~180g)	Tanks	10	80	Higher size variation at low densities, indicating the presence of possible dominance hierarchies
Growth Rate	Atlantic Salmon	Post-smolts (~494g)	Recirculating Aquaculture System	10	53	Fish stocked at 28–53 kg/m^3 weighed less after 66 days than those stocked at either 18 or 19–36 kg/m^3, and growth rate was highest at the lowest tested density (9–18 kg/m^3)
	Arctic Charr	Juvenile (~177g)	Tanks	30	150	Impaired growth rates and feeding efficiency at very high but also at very low densities, when compared with moderate densities
	Rainbow Trout	Juvenile (~43g)	Tanks	20	80	Reduced growth, lower growth rate, and lower feed intake after 60 days at high densities

Reference: Farmed Salmonids Code of Practice Scientific Committee (2020) Biodensity. In: *Code of Practice for the Care and Handling of Farmed Salmonids: Review of Scientific Research on Priority Issues*. Lacombe, AB: National Farm Animal Care Council.

Appendix E – Welfare Indicators

Welfare indicators to be assessed on a rearing unit basis				
		No welfare concerns	**Some welfare concerns**	**Serious welfare concerns**
Action	Intervention	**None**	**Investigation needed**	**Immediate intervention needed**
	Management Practices	**Continue management practices**	**Evaluate management practices**	**Improve management practices**
Welfare Indicator[2]	Feeding Response	Normal[1] feeding behaviour	Minor change in appetite from normal[1]	Significant change in appetite from normal[1]
	Aggression	No aggression	Minor increase in aggression from normal[1]	Significant aggression including fin picking or causing damage to other fish
	Swimming Behaviour	All fish showing normal[1] swimming patterns	Slightly abnormal swimming patterns	Major difficulty in maintaining swimming position
	Size Variation and Condition Factor	Size variation present but small individuals appear to be in good condition	Size variation present and <2% of individuals with poor condition factor (< 0.9)	Size variation present and > 2% of the population with poor condition factor (< 0.9)
	Eye Condition	No visible issues	<2% of individuals with visible eye issues	>2% of population with one or more visible eye issues
	Skin Condition	No visible wounds	<2% of individuals with visible wounds	> 2% of population with one or more visible wounds
	Fin Condition	No visible fin damage	< 2% of population with ≥ 25% of one or more fins missing	>2% of population with ≥ 50% of one or more fins missing
	Water Quality	Good water quality	Slight deterioration in water quality	Major deterioration in water quality
	Growth Rate	Within expected[1] growth rate	Minor deviation from growth rate	Significant deviation from growth rate

Appendix F – Assessing Fish Behaviour during the Crowding Procedure

Reproduced with kind permission of Alastair Smart of Smart Aqua, Aquaculture, Hazelwood Park, South Australia.

1. Goal: low stress, no vigorous activity

- ✓ Fish in the sides of the crowd swimming slowly
- ✓ Normal swimming behaviour, but not all in the same direction
- ✓ No dorsal fins on surface
- ✓ No white sides on surface

2. Acceptable: some fins on surface

- ✓ Normal swimming behaviour at suction point, low stress
- ✓ Few dorsal fins on surface
- ✓ No white sides on surface

3. Undesirable:

- Over-excited swimming behaviour (different directions)
- More than 20 dorsal fins on surface
- Some white sides constantly on surface

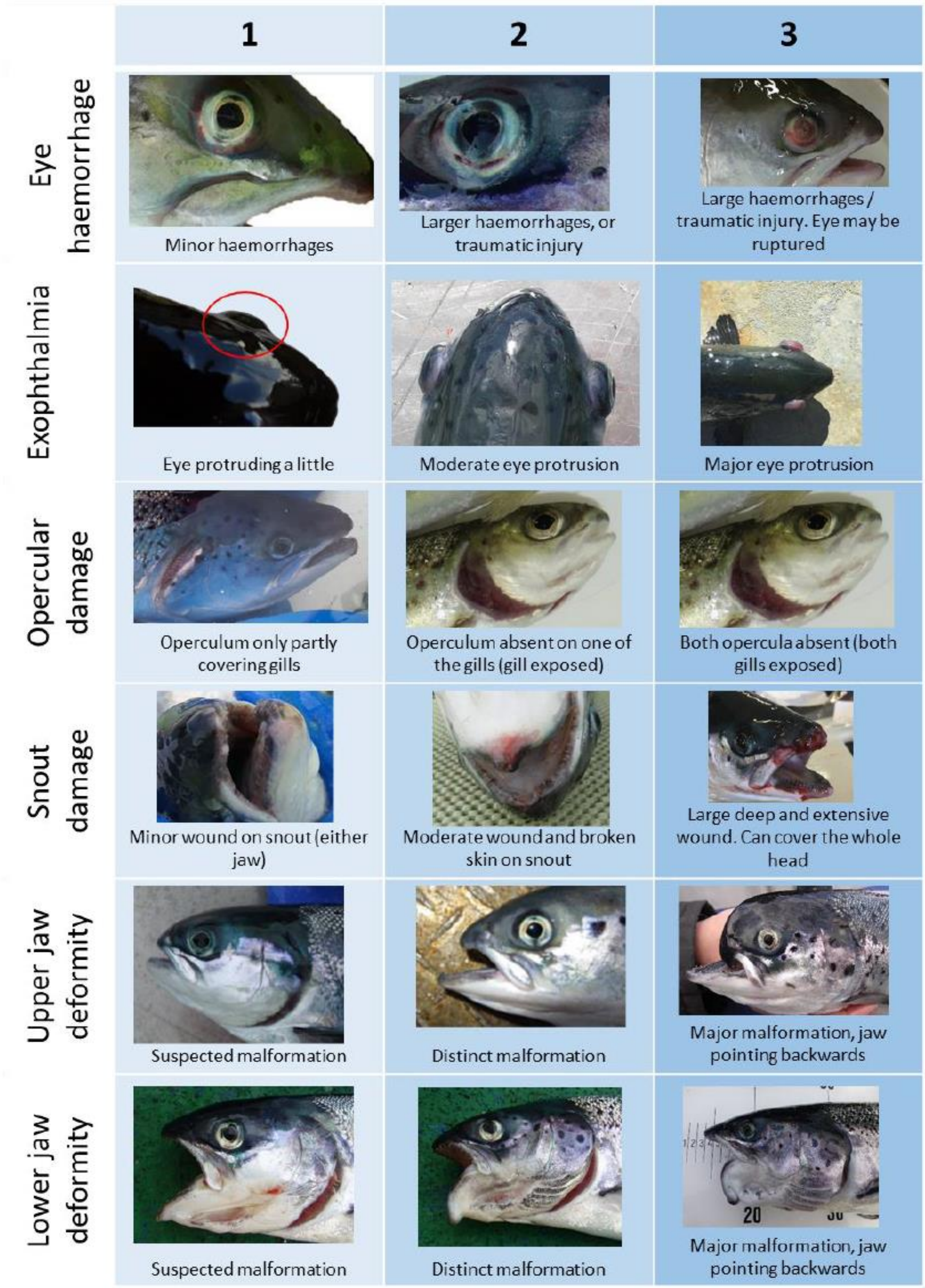
4. Unacceptable: overcrowding

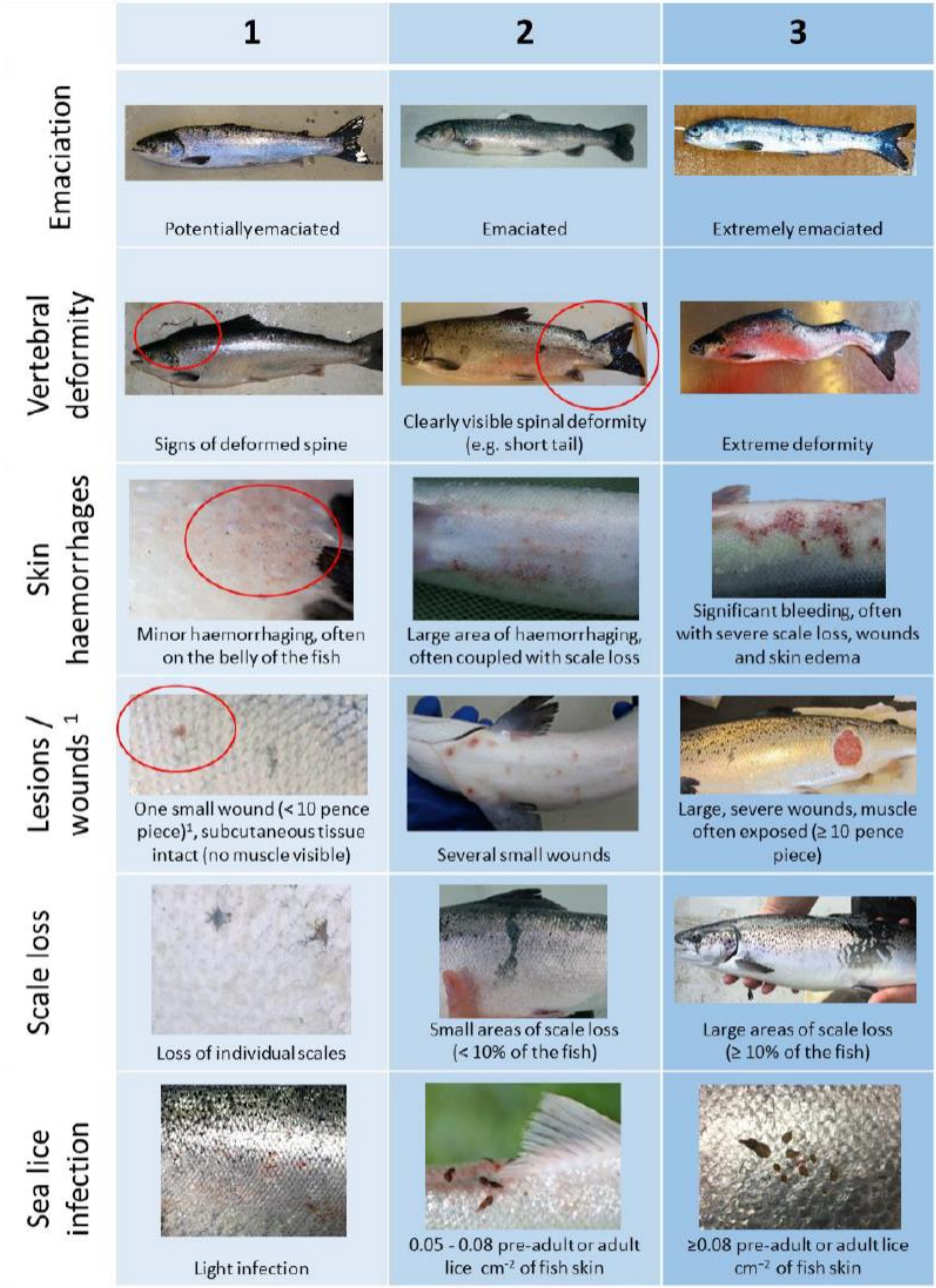
- Over-excited swimming behaviour (different directions). Some fish decreasing activity
- Pumping rate: Not possible to keep a constant rate
- Many fish stuck up against the crowd net
- Many dorsal fins on surface and numerous white sides on surface
- A few very lethargic fish

5. Unacceptable: extreme overcrowding

- Whole crowd boiling
- Potential for large fish kill without rapid release
- *Panic in the population, the fish are exhausted*
- *Many fish floating on their side*

Appendix G – Scoring Fish Welfare Indicators





Source: Noble C., Gismervik K., Iversen M.H., Kolarevic J., Nilsson J., Stien L.H. & Turnbull J.F. (Eds.) (2018). Welfare Indicators for farmed Atlantic salmon: tools for assessing fish welfare. 351pp. ISBN 978-82-8296-556-9. Used with permission.

Appendix H – Troubleshooting Injuries

Injury	Risk Factor	Mitigation
Eyes		
Cataracts	Diet formulation	Use a balanced diet for each specific species
	Parasitic infections	Implement biosecurity measures to prevent pathogen entry
	High UV	Avoid using farms located in zones with high ultraviolet incidence. Cover tanks with lids. Ensure adequate enclosure depth.
	Pollutants	Use clean water free of pollutants to culture fish. Monitor water quality
Eye Injuries (general)	Pumping	Use a vacuum pump to transfer large numbers of fish
Eye protrusion (exophthalmia)	Gas super-saturation	Check aeration of water, monitor gas levels
Head		
Lower Jaw Deformity Syndrome (LJD)	Diet formulation	Ensure diets contain appropriate levels of phosphorus and vitamins A, C, D and K
	Triploidy	Ensure a balanced diet is fed. Improve triploid production techniques
Lesions, tissue erosion and haemorrhaging around mouth	Choice of rearing system	Ensure appropriate materials are used for netting and tanks.
Pug-headedness (brachygnathia)	Inappropriate egg incubation temperatures	Use optimal egg incubation temperatures for species
Early life stage jaw deformities	Inappropriate rearing temperatures	Use appropriate rearing temperatures for species
Fin		
Fin damage	Diet formulation	Select appropriate protein and lipid sources
	Underfeeding	Feed to satiation
	Choice of feed regime	Use demand feeding systems
	Choice of rearing system	Farm fish in flow-through tanks or optimize flow dynamics in RAS tanks
		Incorporate cobble substrates into salmonid raceways during construction
		Omit baffles during raceway construction
		Limit pen submergence to periods <6 weeks
	Inappropriate rearing temperatures	Use appropriate rearing temperatures

	High stocking density	Reduce stocking densities
	Low stocking density	Increase stocking densities
	Low water current	Optimize water current
	Direct aggression	Reduce feeding aggression and competition by delivering multiple feedings and dispersing feed over wide surface area
Skin		
Ulcers	Parasitic infections	High salinity (>12–15 ppt). Low water temperature (>10C)
		Use of antimicrobials at the correct dose
		Reduce stocking densities, disinfection of pens and equipment, restrict fish transport and control of natural host
		Implement biosecurity measures to prevent pathogen entry (disinfection, transport restrictions)
Injuries (general)	Pumping	Use vacuum pumps or turbine pumps at no more than 330 rpm
	Vaccination	Use mineral oil–based adjuvants
	Jellyfish blooms	Use jellyfish traps
Abrasion	High UV	Avoid using farms located in zones with high ultraviolet incidence. Cover tanks with lids. Ensure adequate enclosure depth.
Thinning and mucous cell opening	Therapeutic medicinal treatment	Use bath with low concentration and for the shortest time
Internal		
Intra-peritoneal adherences	Vaccination	Use mineral oil–based adjuvants

Adapted from Noble C., Cañon Jones H.A., Damsgård B., Flood M.J. Midling K.Ø., Roque A., Sæther B.-S., & Yue Cottee S. (2012) Injuries and deformities in fish: their potential impacts upon aquacultural production and welfare. In: Welfare of Farmed Fish in Present and Future Production Systems. Eds. H. van de Vis, A. Kiessling, G. Flik & S. Mackenzie. Netherlands: Springer, pp. 61–83.

Appendix I – Methods of Euthanasia, Slaughter, and Mass Depopulation

The following is a list of methods that are considered acceptable or unacceptable at specified weight classes. Table I.1 is based on information that was available as of the publishing of this Code of Practice. Further research under the oversight of an ethics review board may result in new, acceptable equipment and/or methods, or the elimination of some current methods. **Methods not listed in Table I.1 are unacceptable at any weight class.**

Use of some drugs or products may impact disposal options and/or prohibit entry of the fish into the food chain (including rendering as fish meal) (2).

Table I.1 Methods that are Acceptable or Unacceptable at Different Weight Classes (adapted from 1, 2, 3, 4, 5)

Fish weight* → Method ↓	≤ 1 g	1 g - 500 g	> 500 g
Maceration	Acceptable	Unacceptable	Unacceptable
Intentional overdose via immersion in anesthetic bath	Acceptable	Acceptable	Acceptable
Manually applied blunt force trauma to the head followed by pithing or exsanguination†	Unacceptable	Acceptable	Acceptable
Percussive stunning device followed by pithing or exsanguination	Unacceptable	Unacceptable‡	Acceptable
Electrical stunning with secondary step when req to ensure death	Acceptable	Acceptable	Acceptable
Decapitation with prior stunning or sedation if required to facilitate handling	Unacceptable	Acceptable	Acceptable
Cervical transection followed by pithing	Unacceptable	Acceptable	Acceptable
Pithing with prior stunning or sedation if required to facilitate handling	Unacceptable	Acceptable	Acceptable

*Weights are based on average weight of the specific salmonid species.

†Manually applied blunt force trauma does not reliably result in rapid, irreversible insensibility and a secondary step (pithing or exsanguination) is required to ensure death (2, 5).

‡Devices can be accurately calibrated to reliably stun and kill fish at or just below 500 g. Follow the manufacturer's specifications; devices must be calibrated for the size of fish on which they are being used.

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(1) American Veterinary Medical Association (AVMA) (2020) AVMA Guidelines for the Euthanasia of Animals: 2020 Edition. Schaumburg, IL: American Veterinary Medical Association. Available https://www.avma.org/sites/default/files/2020-01/2020_Euthanasia_Final_1-15-20.pdf Accessed February 20, 2020.
(2) American Veterinary Medical Association (AVMA) (2016) AVMA Guidelines for the Humane Slaughter of Animals: 2016 Edition. Schaumburg, IL: American Veterinary Medical Association. Available https://www.avma.org/sites/default/files/resources/Humane-Slaughter-Guidelines.pdf Accessed February 28, 2020.
(3) American Veterinary Medical Association (AVMA) (2019) AVMA Guidelines for the Depopulation of Animals: 2019 Edition. Schaumburg, IL: American Veterinary Medical Association. https://www.avma.org/sites/default/files/resources/AVMA-Guidelines-for-the-Depopulation-of-Animals.pdf
(4) World Organisation for Animal Health. (2019) Welfare aspects of stunning and killing of farmed fish for human consumption. Available https://www.oie.int/index.php?id=171&L=0&htmfile=chapitre_welfare_stunning_killing.htm Accessed February 12, 2020.
(5) World Organisation for Animal Health. (2019) Chapter 7.4 Killing of farmed fish for disease control purposes. In Aquatic Animal Health Code. Available https://www.oie.int/index.php?id=171&L=0&htmfile=chapitre_killing_farm_fish.htm. Accessed February 12, 2020.

Appendix J – Transport Decision Tree

FIT ANIMALS

TRANSPORT

- Those that are expected to arrive at their final destination in good condition
- According to the Health of Animals Regulations Part XII

COMPROMISED ANIMALS

TRANSPORT DIRECTLY TO THE NEAREST PLACE*

- Has a condition that affects the gills
- Has a condition that causes anemia
- Exhibits any other signs of infirmity, illness, injury or of a condition that indicates that the group has a reduced capacity to withstand transport

***SPECIAL PROVISIONS**

For Compromised & Unfit Groups of Fish

- Measures must be taken to prevent suffering, injury or death during loading, confinement, transport and unloading. Some examples include:
- Slow shipping, lower density, increased monitoring frequency

UNFIT ANIMALS

DO NOT TRANSPORT EXCEPT FOR VETERINARY CARE ON THE ADVICE OF A VETERINARIAN*

- Is unable to swim or maintain position in the school
- Moribund (dying)
- Exhibits signs of a generalized nervous system disorder (e.g. abnormal eye movements or swimming patterns)
- Has laboured breathing (i.e. increased rate and range of opercular movements, gulping for air)
- Has a severe open wound or a severe laceration
- Is extremely thin
- Is bloated to the extent that it exhibits signs of discomfort or weakness
- Exhibits signs of exhaustion
- Exhibits signs of active infectious disease
- Incomplete smoltification if being moved to saltwater
- Improper sedation (if used)
- Exhibits any other signs of infirmity, illness, injury or of a condition that indicates that the group cannot be transported without suffering

Appendix K – Resources for Further Information

PRODUCER MENTAL HEALTH SUPPORTS

- Canadian Mental Health Association https://cmha.ca/
- The Do More Agriculture Foundation https://www.domore.ag/

GENERAL FISH CARE

- Merck Animal Health (n.d.) Aqua Care 365 Farm Fish Behaviour Training Module. Available at https://www.merck-animal-health-usa.com/aqua-care-365
- Noble C., Gismervik K., Iversen M. H., Kolarevic J., Nilsson J., Stien L. H. & Turnbull J. F. (Eds.) (2020). Welfare Indicators for farmed rainbow trout: tools for assessing fish welfare. 310 pp. Available at https://nofima.no/wp-content/uploads/2020/05/Welfare-Indicators-for-farmed-rainbow-trout-Noble-et-al.-2020.pdf
- Noble C., Gismervik K., Iversen M. H., Kolarevic J., Nilsson J., Stien L. H. & Turnbull J. F. (Eds.) (2018). Welfare Indicators for farmed Atlantic salmon: tools for assessing fish welfare 351pp. Available at https://nofima.no/wp-content/uploads/2018/11/FISHWELL-Welfare-indicators-for-farmed-Atlantic-salmon-November-2018.pdf

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- Powell A., Treasurer J.W., Pooley C. L., Keay A.J., Lloyd R., Imsland A.K, Garcia de Leaniz C. (2018) Use of lumpfish for sea-lice control in salmon farming: challenges and opportunities. *REVIEWS IN Aquaculture*, 10:683-702. Available at: https://onlinelibrary.wiley.com/doi/epdf/10.1111/raq.12194

- Royal Society for the Prevention of Cruelty to Animals (2018) Welfare Standards for Farmed Atlantic Salmon. Available at: https://science.rspca.org.uk/sciencegroup/farmanimals/standards/salmon

FISH HEALTH MANAGEMENT

- Danner, G.R. and Merrill P. (2006). Disinfectants, Disinfections and Biosecurity in Aquaculture. *In:* A.D. Scarfe, C. Lee, and P.J. O'Bryen (eds.). *Aquaculture Biosecurity: Prevention, Control, and Eradication of Aquatic Animal Disease*. Blackwell Publishing, Ames, Iowa, USA. pp. 91-128.
- Government of Canada (n.d.) Aquatic Animal Diseases. https://www.inspection.gc.ca/animal-health/aquatic-animals/diseases/eng/1299156296625/1320599059508
- Government of Canada (n.d.) Aquatic Animal Biosecurity. Available https://www.inspection.gc.ca/animal-health/aquatic-animals/aquatic-animal-biosecurity/eng/1320594187303/1320594268146

FISH TRANSPORTATION

- Canadian Food Inspection Agency (last modified 2020-05-12) Example Contingency Plan Template. In: *Health of Animals Regulations: Part XII: Transport of Animals Regulatory Amendment Interpretive Guidance for Regulated Parties*. Available https://www.inspection.gc.ca/animal-health/humane-transport/health-of-animals-regulations-part-xii/eng/1582126008181/1582126616914#app2