Global Animal Partnership's

5-Step® Animal Welfare Standards for Farmed Atlantic Salmon v1.0

About Global Animal Partnership's (G.A.P.) Animal Welfare Certified™ Program

G.A.P.'s Animal Welfare Certified™ Program consists of a series of species specific multi-tiered standards designed to assess farm animal welfare within different production systems. Each set of tiered standards—from Step 1 to Step 5+—has its own requirements that must be met before certification to that particular Step level is achieved.

As the standard-setter, Global Animal Partnership does not conduct audits nor make Step-level certification decisions but rather accredits third-party certifiers to administer the Program. Authorized third-party certifiers perform the audits and issue Step certificates, as appropriate. As such, producers, consumers, and retailers alike can be confident that Step-levels are fair, accurate, and free of conflict of interest.

In order for a company/brand to use the G.A.P. label in the marketplace, 100% of the product must come from farms that hold a current G.A.P. certificate. Use of the G.A.P. label is governed by G.A.P.'s Labelled Product Authorization program (LPA) and the regulations of the country the label is used in.

G.A.P. believes that meaningful label claims, validated by third-party audits on every farm, are key to influencing the industry, raising consumer expectations, and creating long-lasting change for animals.

About G.A.P.'s 5-Step® Animal Welfare Standards for Farmed Atlantic Salmon

G.A.P.'s 5-Step® Animal Welfare Standards for Farmed Atlantic Salmon v1.0 was issued on June 8, 2022. The development process included consultation with salmon aquaculture industry experts and consultants, from our Scientific Advisory Committee* and our Technical Working Group, an extensive consultative process, and review and approval by the Global Animal Partnership Board of Directors.

G.A.P.'s 5-Step® Animal Welfare Standards for Farmed Atlantic Salmon v1.0 covers the management of ova, juvenile Atlantic salmon, smolts, and adults at all stages and type of production including slaughter.

After three (3) certification cycles, the standards will be reviewed and revised based on key learnings from the launch, as well as any new, relevant scientific findings. The post-review and revision process will again involve guidance from scientific experts and producers, field testing and public comment, before the

* For more information on G.A.P.'s Scientific Advisory Committee, please visit www.globalanimalpartnership.org.

draft revision is presented to the Board of Directors for final review and approval. Thereafter, the standards will be reviewed and revised according to the protocol outlined in the G.A.P. Policy Manual.

G.A.P.'s expertise lies in creating robust, third-party audited welfare standards. While our standard focuses on animal welfare, we want to support partner efforts that also take environmental sustainability into account and are seeking strategic partners who share that belief.

At any time throughout the above-mentioned period, G.A.P. may clarify parts of the standard as issues with implementation arise, new technologies become available, or new scientific findings are made.

About Global Animal Partnership

Global Animal Partnership, a nonprofit charitable organization founded in 2008, brings together farmers and ranchers, scientists, retailers, food manufacturers and animal advocates—a diverse group with the common goal of wanting to improve the welfare of animals in agriculture.

For more information, contact us at info@globalanimalpartnership.org or 877.427.5783.

Program Overview

The marketing claims in this Program Overview apply only to farmed Atlantic salmon. The Step levels for farmed Atlantic salmon distinguish between management practices, not production systems. For example, for Steps 1 and 3, salmon may be transported to slaughter but Step 5+ requires that slaughter be carried out on-site, either by a harvest vessel or at the operation for land-based RAS facilities. Environmental enrichments are required at all Step levels, as the Steps increase so too does the number and variety of enrichments required. Step 1 and 3 operations may use cleaner fish as part of their sea lice management and mitigation efforts, but they are prohibited at Step 5+. Regardless of production system, an Atlantic salmon farm has the ability to achieve their desired Step Level if they can meet all the requirements of that Step level.

Step Level	Marketing Claims	Management Highlights
	**Animal Welfare Certified**	Atlantic salmon are provided with enrichment at all life stages and are given ample space to swim (low stocking densities), regardless of production system. If cleaner fish (fish which are stocked into marine net pens for the sole purpose of eating/removing sea lice from salmon) are used on-farm, they must be provided with enrichments and shelters. Certain sea lice treatments are prohibited. No physical alterations. Water quality is monitored daily. No lethal action against predators allowed. The use of auditory deterrent devices (ADDs)/auditory harassment devices (AHDs) to deter predators is prohibited after January 1, 2024. Environmental sustainability plan required.
There is no Step 2		
	**Enhanced Habitat**	More enrichments at all life stages are required. If cleaner fish are used on-farm, they must be provided with enrichments and shelters and only re-stocked once during the production cycle. The use of auditory deterrent devices (ADDs)/auditory harassment devices (AHDs) to deter predators is prohibited. Fish cannot be transported longer than 24 hours. Environmental sustainability plan required.
There is no Step 4		
There is no Step 5		
	**Fish Centered**	Salmon are provided with multiple enrichments at all life stages. Sea lice and fin, skin and body condition monitoring are done without removing salmon from water. The use of cleaner fish is prohibited. The use of auditory deterrent devices (ADDs)/auditory harassment devices (AHDs) to deter predators is prohibited. Environmental sustainability plan required. Fish must be slaughtered cage-side (for open water grow-out) or on-site (for RAS facilities).

How to Read these Standards

Standards applicable to a Step level are designated with a • symbol in the corresponding Step column. The Ⓜ indicates the standard is considered a major non-conformance (see Non-conformances section below for more details). If there is a Ⓒ beside the standard it is considered a critical non-conformance (see Non-conformances section below for more details).

In the example below, the standard is required for each Step level: Step 1, Step 3 and Step 5+. In addition, the ⓘ symbol prefaces additional information provided to aid in the understanding of the standard:

STANDARD		Step Level					
		1	2	3	4	5	5+
1.1 Source / Breed / Lines							
1.1.2	Triploid salmon are prohibited from being marketed as G.A.P. Certified.	•		•			•
	ⓘ **[1.1.2]:** *G.A.P. understands the issues with farmed salmon introgression into wild salmon populations. While triploid salmon can minimize the impact of escapees on wild populations, given that there are specific welfare concerns related to triploid salmon production and current research is limited regarding how best to address those specific concerns, at this time triploid salmon are prohibited from the Program.*						

In this example, 8.2.3 is required only for Step 1, and 8.2.4 is required only for Steps 3 and 5+:

STANDARD		Step Level					
		1	2	3	4	5	5+
8.2 Sea Lice Prevention ⓘ *G.A.P. recognizes that sea lice are one of the largest challenges facing the farmed salmon industry, and that preventative methods are the first step to mitigating sea lice levels.* ⓘ *G.A.P. defines a "prevention method" as a proactive method which is planned and implemented prior to reaching any sea lice thresholds.* ⓘ *See Appendix IX for further details of sea lice prevention.*							
8.2.3Ⓜ	The operation must use at least 1 acceptable lice prevention method at any given time (see Appendix IX for further details on acceptable/unacceptable prevention methods).	•					
8.2.4	The operation must use at least 2 different acceptable lice prevention methods at any given time (see Appendix IX for further details on acceptable/unacceptable prevention methods).			•			•

Additionally, some standard headers specify a standard that is applicable only to freshwater or seawater production. In the example below, Standards 2.8.3 and 2.8.4 only apply to Freshwater Production:

STANDARD		Step Level					
		1	2	3	4	5	5+
2.8 Mortality							
Freshwater Production Only							
2.8.3	Average monthly pen/tank mortality must not exceed 1.0% during freshwater production.	•					
2.8.4	Average monthly pen/tank mortality must not exceed 0.70% during freshwater production.			•			•

Some standards within this document are marked R for Recommended. These recommended standards list best practice and/or areas where during the launch and implementation of this version of the standard, G.A.P. will undertake research to determine the requirements for future standards. Recommended standards do not affect the final result of certification. Failure to meet a recommended standard does not give rise to a non-conformance. However, auditors will collect information on recommended standards to give G.A.P. greater insight to current practices.

This example illustrates that the standard is recommended:

Removing Cleaner Fish at End of Production and Management During Treatment– Recommended (R)	
R1	At the end of the salmon production cycle, cleaner fish must be removed prior to salmon being fasted for slaughter.

Program Requirements

The following is applicable to each operation applying for certification to Global Animal Partnership's 5-Step® Animal Welfare Standards for Farmed Atlantic Salmon.

Producer resources, prep tools and other Program Documents can be found at www.globalanimalpartnership.org

1. General

a. The standards in this document are requirements.
b. The operation must have read the standards and prepared for the audit or they cannot be certified.
c. With the exception of Standard 1.1.3, standards for breeding fish (broodstock) are not included in this document and will be developed in the future.
d. Unless otherwise specified, standards in this document pertain to market salmon of any age. The standards in this document also include standards for cleaner fish. Any standard which applies just to salmon will indicate "salmon" but if the standard uses the term "fish" that applies to both salmon and cleaner fish.
e. The term "stock" is defined as the total population of fish at any given time on a single operation.
f. The term "operation" is defined as either (i) a single farm or (ii) a farm with more than one location, that meets all of the following criteria:
    i. all staff and fish are under the direct supervision* of the main farm;
    ii. the main farm owns all of the fish; and
    iii. the main farm owns, rents or leases, all the land (including any underwater land area), sea pens, support vessels (feed barge) and/or buildings (hatcheries) where the fish are kept.

    An individual operation can include a farm that is under contract to raise juvenile fish for a larger business OR a farm that owns their own fish and markets them under their own brand(s).

    **Direct supervision is defined as being when an employee of the main certified farm business is responsible for the fish on the farm that is at a separate location to the main farm. If the person responsible for the management and care of the fish at a separate location to the main certified farm business is a contract farmer and not an employee, then that site is a separate operation for the purposes of determining the number of audits – even if there is routine oversight from an employee of the main operation.*
g. All parts of the supply chain must be G.A.P. Certified in order to use the G.A.P. label (including farms, processors and brands). Farms must adhere to this standard. Processors and brands must adhere to G.A.P.'s Labeled Product Authorization Program.
h. The G.A.P. Policy Manual is a companion document to the standards, and details additional program requirements and terms of certification beyond that which is included in the standards (see www.globalanimalpartnership.org for a copy of the Policy Manual).
i. A glossary defining specific terms and terminology used in these standards is located at the end of this document.
j. No standard in this document supersedes governmental regulations or laws, whether local, regional, state, provincial, territorial, federal, national, or other.
k. If an operation produces both G.A.P. Certified salmon and non-G.A.P. Certified salmon on the same site (e.g. where there are multiple pens or tanks managed to different programs), this is defined as a split operation. In order to qualify as a split operation, a strict segregation protocol must be in place and approved by the certifier prior to a G.A.P. certification decision being issued. The segregation protocol must include a written policy describing how salmon from G.A.P. Certified stocks is segregated from salmon from non-G.A.P. Certified stocks; AND at the time of the audit, the operation will need to

demonstrate evidence of the segregation policy in action. As outlined in the G.A.P. Policy Manual, split operations will not be issued certification to the operation as a whole, rather certificates will specify the certified G.A.P. Certified portion of the split operation.

l. Any use of the G.A.P. label or logo must meet the requirements of G.A.P.'s Brand Book, licensing agreement and be approved by G.A.P. prior to use. Please contact lpa@globalanimalpartnership.org for further details.

2. Applications

a. Each operation is required to submit a completed G.A.P.'s 5-Step® Animal Welfare Farmed Atlantic Salmon application for each certification cycle prior to audit.
b. Each operation must identify all sites (either owned, leased, and/or shared) used to raise Atlantic salmon by the operation on their G.A.P. application.
c. Applications, this document, and other program documents, can be downloaded at www.globalanimalpartnership.org/ or by contacting your G.A.P.-accredited certifier.

3. Audit and Certification

a. Each operation must be audited and certified prior to marketing any product(s) as G.A.P. Certified.
b. Each operation must be audited once every certification cycle. A certification cycle is 18 months, which allows for salmon and operations to be assessed at different times (and potentially during different freshwater/marine conditions) and to provide flexibility when scheduling audits around key production practices.
c. Alternate certification cycle audits (every 3 years) the certifier will schedule the audit around observing a crowding event on-farm.
d. If salmon are not raised on a single operation and different stages of production are conducted by different operations (e.g. salmon are hatched and complete smoltification at hatchery A, and then are transported to location B where from 100g onward they are raised to slaughter weight), each operation must submit a completed G.A.P.'s 5-Step® Animal Welfare Farmed Atlantic Salmon application and be audited and certified prior to product being marketed as G.A.P. Certified.
e. To facilitate implementation of this standard within the context of on-going business, **at initial audit only**, any farmed Atlantic salmon on-site that the operation has sourced from other operations are eligible for certification without requiring an audit of the source farm(s) (i.e. the purchased salmon will be grandfathered into the Program at the time of the initial audit). All grandfathered fish from this initial audit must be inventoried at the time of the initial audit so that they are not disqualified at subsequent audits.
f. At re-certification, any salmon (including ova, juveniles, or smolts) sourced by the operation must come from a G.A.P. Certified source farm if they are going to be marketed as Animal Welfare Certified.
g. Each operation must have salmon (which can be ova, juveniles or smolts) on-site at the time of the on-site audit, but not all pens or tanks at an operation must have salmon in them at the time of the audit.
h. At the time of on-site audit, the person(s) responsible for managing the operation and/or fish caretaker must be present. A designated representative affiliated with a supplier group may also be present at the time of the on-site audit but cannot be the only person present.
i. Each operation applying for G.A.P. certification is responsible for ensuring that all required records and documents are available, and that all applicable standards are met, including actions that may be contracted or managed by another entity (e.g. transport, predator control).

j. All applicable standards, including those that may be controlled or managed by, or contracted to, another (e.g. the genetics company; a transporter; a producer group, co-operative, or marketing entity; slaughter facility), will be assessed for compliance by the certification company and incorporated into its overall assessment of the operation prior to the final Step determination.
k. G.A.P. supports the use of video or other electronic monitoring records for the review of handling procedures (e.g. crowding, pumping, grading) as well as daily pen or tank monitoring. Use of video technology is not a requirement but can be used in place of certain observations listed in G.A.P.'s Policy Manual. Please refer to G.A.P.'s Policy Manual for additional details about how this must be conducted.
l. Auditors do not make Step-level determinations nor provide consultative service to producers on meeting standards requirements; reviewers of authorized certification companies make Step-level determinations.
m. Each Step level—Step 1 through Step 5+—has its own requirements that must be met to be certified to that level. If an operation, for example, meets some but not all Step 3 requirements, but 100% of the requirements for Step 1, then the operation is able to achieve Step 1 certification.
n. If in a particular situation or circumstance, a standard as written might compromise the welfare of the salmon in the producer's care, the producer should contact their accredited certifier to discuss applying to G.A.P. for a deviation.

4. Non-conformances

Note: This section provides a brief overview of the provisions of the G.A.P. Policy Manual relating to non-conformances. For further details please refer to that document.

a. If an operation fails to meet a standard, it will be considered a non-conformance.
b. Any non-conformance identified by the accredited certifier, must be closed out by the certifier prior to a Step-level being assigned and a certificate issued.
c. There are three categories of non-conformance: minor, major and critical.
d. If an operation receives a repeat non-conformance at the time of the next audit – the designation of minor, major and critical impacts the certification decision (see Repeat Non-conformances in G.A.P.'s Policy Manual).
i. In the example below, the C indicates that failure to meet the standard would be considered a critical non-conformance and the operation would be denied certification (see G.A.P.'s Policy Manual for further information).

STANDARD		Step Level					
		1	2	3	4	5	5+
3.2 Handling							
3.2.1 C	Fish must not be mistreated in any way. Mistreatment includes, but is not limited to, kicking, throwing, striking, hitting, deliberately dropping fish, or only holding them by the gills, fins, or tail.	•		•			•
	ⓘ **[3.2.1 a]:** *G.A.P. has a zero-tolerance policy to kicking, throwing, striking, hitting, dropping, or only holding fish by gills or fins and any other actions or omissions in care that could cause harm or injury to salmon or cleaner fish species.* ⓘ **[3.2.1 b]:** *Proper and respectful handling extends to all salmon or cleaner fish species – healthy, sick, injured and/or dead.*						

ii. In the example below, the Ⓜ indicates that failure to meet the standard would be considered a major non-conformance. If, at recertification, this standard was still not in compliance, the category is escalated from a major to a critical and the operation is denied (see G.A.P.'s Policy Manual for further information).

STANDARD		Step Level					
		1	2	3	4	5	5+
1.1 Source / Breed / Lines							
1.1.1 Ⓜ	Intentional use of genetically modified or cloned salmon, their progeny, or their eggs and milt is prohibited.	•		•			•

iii. In the example below, as there is no Ⓜ or Ⓒ beside the standard, this means that the standard is classified as a minor non-conformance if it fails to be met. If at recertification, this standard was still not in compliance, then the category is escalated from a minor to a major non-conformance. If at the third certification cycle, this standard was still not in compliance, then the category is escalated further from a major to a critical non-conformance and the operation is denied certification (see G.A.P.'s Policy Manual for further information).

STANDARD		Step Level					
		1	2	3	4	5	5+
5.5 Equipment and Hazards Management							
5.5.1	Equipment, nettings, fittings, and protrusions must not injure fish.	•		•			•

e. If an operation is issued a major or minor non-conformance, it needs to be addressed and the response submitted to the certifier by the operation within 3 weeks from the date the certifier issues the audit report and be accepted by the certifier as an acceptable response to the non-conformance, before a certificate is issued. If the operation does not respond to the non-conformance within 3 weeks, it will result in a shortened certificate once an acceptable response is received (see G.A.P.'s Policy Manual).

f. At renewal, if an operation fails to meet a standard that is specific to their Step-level, it will drop to the applicable Step-level, or lose certification as appropriate, unless the Certifier applies their discretion to issue a non-conformance **if and only if**:
   i. the standard that is out of conformance is not a repeat from the previous audit; and
   ii. the Certifier is confident the operation will be able to achieve and maintain the level specified in the standard; and
   iii. the operation is only out of conformance with one standard relating to the Step level the operation is looking to achieve.

TABLE OF CONTENTS

ⓘ*G.A.P. recognizes that both farm animal welfare and sustainability are inextricably linked. We believe that fish welfare is as important as a fish farm's environmental sustainability, and we are seeking strategic partners who share that belief. See Standard 12.4 for further details and requirements regarding sustainability.*

ⓘ*Certain historical records and documents included in this set of standards may not be available at the time of initial audit as the operation applying for G.A.P. Certification was unaware they would be required to monitor and/or record them and, therefore, cannot create them for past events, treatments, assessments, or practices. At the time of initial audit, record-keeping, protocols and documentation mechanisms must be in place to meet each of these standards and be available for review.*

1 FISH SOURCE

ⓘ*It is G.A.P.'s intention in the future to require that salmon eggs also come from G.A.P. Certified operations; however, at this time, it is recognized that imposing this requirement would be an impediment to securing appropriate salmon stock, therefore sourcing eggs from non-G.A.P. Certified operations is allowed.*

ⓘ*It is G.A.P.'s intention to develop standards for parent stock (i.e. broodstock) in the next version of this Standard.*

STANDARD		Step Level					
		1	2	3	4	5	5+
1.1 Source / Breed / Lines							
1.1.1 Ⓜ	Intentional use of genetically modified or cloned salmon, their progeny, or their eggs and milt is prohibited.	●		●			●
1.1.2	Triploid salmon are prohibited from being marketed as G.A.P. Certified.	●		●			●
	ⓘ **[1.1.2]:** *G.A.P. understands the issues with farmed salmon introgression into wild salmon populations. While triploid salmon can minimize the impact of escapees on wild populations, given that there are specific welfare concerns related to triploid salmon production and current research is limited regarding how best to address those specific concerns, at this time triploid salmon are prohibited from the Program.*						
1.1.3	Breeding stock selection criteria must include disease resistance.	●		●			●

STANDARD		Step Level					
		1	2	3	4	5	5+
1.1 Source / Breed / Lines *Continued*							
1.1.4	Juveniles must be sourced from G.A.P. Certified freshwater rearing facilities. A copy of their G.A.P. certificate must be kept on file.	•		•			•
	ⓘ **[1.1.4 a]:** *See Standards 12.7.1-12.7.2 for records requirements.* ⓘ **[1.1.4 b]:** *Juveniles includes smolt, parr, alevin and fry but not ova.* ⓘ **[1.1.4 c]:** *At the initial audit only, farmed Atlantic salmon on-site at the time of the audit may be grandfathered into the Program - see 3(d) in the Program Requirements for further details.*						

FISH HEALTH

ⓘ *This Section covers general health, treatment, medications, euthanasia, and mortality. For health concerns relating specifically to sea lice please see Section 8 – Sea Lice.*

STANDARD		Step Level					
		1	2	3	4	5	5+
2.1 Veterinarian-Client-Patient-Relationship (VCPR)							
2.1.1	The operation must maintain a Veterinarian-Client-Patient Relationship (VCPR). To substantiate the VCPR, the operation must have a letter on file that states that all components of a VCPR are present (see G.A.P.'s definition of a VCPR in the informational note below), and the letter must be signed and dated by the operation's veterinarian within the previous 12 months.	●		●			●
	ⓘ **[2.1.1 a]:** *G.A.P. has created a template VCPR acknowledgment letter, which the operation can choose to use to substantiate compliance with this Standard. The template can be found at www.globalanimalpartnership.org.* ⓘ **[2.1.1 b]:** *G.A.P. has adopted the American Veterinary Medical Association's (AVMA) definition of a VPCR which states:* *"A VCPR is present when all of the following requirements are met:* *1. The veterinarian has assumed the responsibility for making clinical judgments regarding the health of the patient and the client has agreed to follow the veterinarians' instructions.* *2. The veterinarian has sufficient knowledge of the patient to initiate at least a general or preliminary diagnosis of the medical condition of the patient. This means that the veterinarian is personally acquainted with the keeping and care of the patient by virtue of a timely examination of the patient by the veterinarian, or medically appropriate and timely visits by the veterinarian to the operation where the patient is managed.* *3. The veterinarian is readily available for follow-up evaluation or has arranged for the following: veterinary emergency coverage, and continuing care and treatment.* *4. The veterinarian provides oversight of treatment, compliance, and outcome.* *5. Patient records are maintained."*						
2.2 Treatment							
2.2.1 MM	Sick or injured salmon must be monitored, promptly treated or euthanized according to Section 2.7	●		●			●

STANDARD		Step Level					
		1	2	3	4	5	5+
2.2 Treatment *Continued*							
2.2.2	Records must be kept of any treatment (medication, vaccinations, alternative remedies, probiotics etc.) given to any individual salmon or group of salmon, and include: a. year class/stock identification; b. number of individuals treated; c. any substance administered and its batch number; d. date and method of administration; e. name of administrator; and, f. withdrawal period. g. For any sea lice treatment, the treatment method used.	●		●			●
2.2.3	Veterinarian-prescribed treatments must be administered according to veterinarian guidance.	●		●			●
2.2.4	Records of disease outbreaks are required, and must include: a. date of outbreak; b. percentage of infected salmon per pen or tank; c. actions taken to address the outbreak; d. outcomes of the actions taken to address the outbreak.	●		●			●
	ⓘ **[2.2.4]:** *A disease outbreak is defined as any disease that affects 1000 or more fish.*						
2.3 Medication							
2.3.1C	Salmon that are given antibiotics are prohibited from being marketed as G.A.P. Certified.	●		●			●
	ⓘ **[2.3.1 a]:** *See Standard 2.2.1 for prompt treatment of salmon.* ⓘ **[2.3.1 b]:** *This standard applies whether treatments are given therapeutically or sub-therapeutically.*						
2.3.2	Salmon that are given organophosphates are prohibited from being marketed as G.A.P. Certified.	●		●			●
2.3.3	Salmon that are given growth hormones are prohibited from being marketed as G.A.P. Certified.	●		●			●
2.3.4	A written protocol must be in place to identify and ensure that any salmon given antibiotics, organophosphates, or growth hormones are not marketed as G.A.P. Certified.	●		●			●
	ⓘ **[2.3.4]:** *This protocol should include identifying treated pens or tanks.*						
2.3.5	Off-label / extra-label use of medicines is prohibited unless prescribed by a veterinarian following country specific regulations.	●		●			●
2.3.6	Expired medication must not be administered to any fish.	●		●			●

STANDARD		Step Level					
		1	2	3	4	5	5+
2.3 Medication *Continued*							
2.3.7	Any expired medication must be properly disposed of.	●		●			●
2.3.8	Administering clove oil to fish is prohibited.	●		●			●
	ⓘ **[2.3.8]:** *See also Standard 2.5.2. for acceptable anesthetics.*						
2.4 Vaccination ⓘ *G.A.P. doesn't require operations to vaccinate salmon however, G.A.P. understands that operations may need to vaccinate against infectious pancreatic necrosis virus (IPNV), infectious salmon anemia virus (ISAV), infectious hematopoietic necrosis virus (IHNV), salmon alphaviruses (SAV), as well as other viral, bacterial or fungal infections and this Section has requirements about vaccination procedures and salmon-based outcomes.* ⓘ *This Section (2.4) applies only to operations which carry out vaccination.* ⓘ *Adhesions are bands of scar-like tissue that form between two surfaces inside the body that are not normally joined together; such as between internal organs or between an internal organ and the body wall. Vaccination adhesions can result from improper vaccine delivery.* ⓘ *See Appendix I for Vaccine Adhesion scoring protocols and procedures.*							
2.4.1	Vaccination must be carried out by a trained person(s).	●		●			●
	ⓘ **[2.4.1]:** *See also Section 12.6 (Training). Trained individuals may include veterinarians or fish health professionals.*						
2.4.2	Salmon must be anesthetized prior to a vaccination injection.	●		●			●
	ⓘ **[2.4.2 a]:** *See Standard 2.5 (Anesthesia).* ⓘ **[2.4.2 b]:** *Other methods of vaccination delivery (e.g. feed or water) do not require salmon to be anesthetized.*						
2.4.3	Vaccination Adhesion scoring must take place at slaughter for every shipment of G.A.P. salmon processed per the protocols in Appendix I.	●		●			●
	ⓘ **[2.4.3 a]:** *This is only for salmon that are vaccinated via injection per Standard 2.4.2.* ⓘ **[2.4.3 b]:** *See Appendix I for details about sampling and scoring.* ⓘ **[2.4.3 c]:** *See G.A.P.'s Farmed Atlantic Salmon Animal Welfare Slaughter Facility Standard v1.0.* ⓘ **[2.4.3 d]:** *At the time of initial audit, record-keeping and documentation mechanisms must be in place to meet Standard 2.4.3.*						

STANDARD		Step Level					
		1	2	3	4	5	5+
2.4 Vaccination *Continued*							
2.4.4	Records must be kept of Vaccine Adhesion scores on every shipment of G.A.P. salmon processed for at least 18 months.	●		●			●
	ⓘ **[2.4.4]:** *G.A.P.'s goal is to set a standard for a maximum threshold percentage of Vaccine Adhesion scores above 4. During the launch and implementation of this version of the standard, G.A.P. will collect information on vaccine adhesion scoring to determine the threshold in the next version of the standard. At this time, we recommend that Vaccine Adhesions scores ≥ 4 do not exceed an annual average of 10%.*						
2.5 Anesthesia ⓘ *Anesthesia must be carried out during the following procedures: vaccination (Standard 2.4.1); if fish are out of water longer than 10 seconds (Standard 3.2.3); and if Passive Integrated Transponder (PIT) tags are injected (Standard 3.3.3).*							
2.5.1	All anesthesia administration must be carried out by a trained person(s) or veterinarian.	●		●			●
	ⓘ **[2.5.1]:** *See also Section 12.6 (Training). Trained individuals may include veterinarians or fish health professionals.*						
2.5.2 Ⓜ	Acceptable anesthetic drugs include: a. tricaine methane sulfonate (MS-222); b. isoeugenol; c. benzocaine; and d. metomidate.	●		●			●
	ⓘ **[2.5.2 a]:** *Administration of anesthetics on farmed fish must not violate any local, state, provincial, territorial, federal, national, or other laws and regulations.* ⓘ **[2.5.2 b]:** *If an operation wishes to use an anesthetic not listed above, they need to seek approval from G.A.P. prior to using it.* ⓘ **[2.5.2 c]:** *The use of clove oil as an anesthetic is prohibited. See Standard 2.3.8.*						
2.6 Culling ⓘ*G.A.P. defines culling as a fish that has been removed by a caretaker and euthanized as a health management decision.*							
2.6.1	Any salmon meeting the following criteria must be culled and euthanized in accordance with Section 2.6: a. Emaciation score ≥ 2 (See Appendix VI); b. Extreme jaw deformities (See Appendix III for examples); c. Extreme opercular deformities (See Appendix III for examples); d. Extreme spinal deformities (see Appendix III for examples); or e. Growth-stunted salmon (runts).	●		●			●

STANDARD		Step Level					
		1	2	3	4	5	5+
2.7 On-Farm Euthanasia ⓘ *This Section and the methods listed in this Standard relate to on-farm euthanasia of all fish (including cleaner fish). For standards on slaughter please see Section 13 and G.A.P.'s Farmed Atlantic Salmon Animal Welfare at Slaughter Facility Standard v1.0.* ⓘ *G.A.P. defines on-farm euthanasia as the act of killing individual fish in response to an irrecoverable illness or injury or inability to thrive.* ⓘ *If emergency euthanasia of the entire stock or large proportion of the pen/tank is necessary due to a disease outbreak, this Section does not restrict the actions of the farm if the conditions or circumstances require them to take action as guided by a veterinarian or regulatory official.*							
2.7.1	All on-farm euthanasia must be performed by a trained person(s) or veterinarian.	●		●			●
	ⓘ **[2.7.1 a]:** *Producers will not be required to euthanize a fish in order to show compliance with this standard, but they must be able to describe the training they have received whether this is experiential or formal.* ⓘ **[2.7.1 b]:** *See also Standard 12.6 (Training). Trained individuals may include veterinarians or fish health professionals.*						
2.7.2	If a fish is identified as requiring euthanasia, they must be euthanized promptly using an acceptable method listed in Standard 2.7.4.	●		●			●
	ⓘ **[2.7.2 a]:** *This standard includes cleaner fish.* ⓘ **[2.7.2 b]:** *Timely euthanasia is important. Ideally, a fish identified as requiring euthanasia will be euthanized immediately; however, G.A.P. understands the difficulties of locating and catching individual fish and this may impact the time taken to carry out the procedure.*						
2.7.3 Ⓜ	Euthanasia technique(s) must cause rapid insensibility and be immediately followed by death. Salmon must not be allowed to regain consciousness prior to death.	●		●			●
	ⓘ **[2.7.3]:** *The operation must be able to describe to the auditor the visual indicators of death, and the physical parameters that confirm this.*						

<table>
<tr><th colspan="2" rowspan="2">STANDARD</th><th colspan="6">Step Level</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>5+</th></tr>
<tr><td colspan="8">2.7 On-Farm Euthanasia Continued</td></tr>
<tr><td>2.7.4</td><td>Acceptable and unacceptable methods of euthanasia are listed in the table below:
<table>
<tr><th>Method of Euthanasia</th><th>Fish up to 80 g liveweight</th><th>Fish greater than 80 g liveweight</th></tr>
<tr><td>Anesthetic overdose</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Use of a small baton with a weighted end or priest followed immediately by a secondary method which ensures death (i.e. gill cutting or exsanguination)</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Automated percussive stunning followed immediately by a secondary method (i.e. gill cutting or exsanguination) which ensures death</td><td>No</td><td>Yes</td></tr>
<tr><td>Ice bath or ice slurry</td><td>No</td><td>No</td></tr>
<tr><td>Live chilling</td><td>No</td><td>No</td></tr>
<tr><td>Carbon dioxide narcosis</td><td>No</td><td>No</td></tr>
<tr><td>Suffocation in air</td><td>No</td><td>No</td></tr>
<tr><td>Exsanguination or gill cutting without prior stunning</td><td>No</td><td>No</td></tr>
</table>
ⓘ [2.7.4]: If an operation wishes to use a method of euthanasia not listed above, written approval from Global Animal Partnership must be received prior to on-farm use, in order to meet this Standard.</td><td>●</td><td></td><td>●</td><td></td><td></td><td>●</td></tr>
<tr><td>2.7.5</td><td>Any handling associated with euthanasia must minimize distress prior to loss of consciousness.</td><td>●</td><td></td><td>●</td><td></td><td></td><td>●</td></tr>
<tr><td>2.7.6</td><td>The person performing euthanasia must ensure the fish is dead before disposal of the carcass.</td><td>●</td><td></td><td>●</td><td></td><td></td><td>●</td></tr>
<tr><td>2.7.7</td><td>Records must be kept of the date, the number of fish euthanized and the reason for euthanasia.</td><td>●</td><td></td><td>●</td><td></td><td></td><td>●</td></tr>
</table>

STANDARD		Step Level					
		1	2	3	4	5	5+
2.8 Mortality ⓘ *There are four categories of mortality: (a) fish that are found dead through natural causes, (b) fish found dead through predation, (c) fish that are culled (see Standard 2.7) and (d) fish that are missing (i.e. escapes).* ⓘ *Though all categories of mortality must be recorded, the percentages used to calculate the mortality thresholds in Standards 2.8.4, 2.8.5, 2.8.6, and 2.8.7, include only salmon that die of natural causes, are predated upon, and culled-points (a), (b) and (c) above. Losses due to escapes are not included in this calculation.* ⓘ *Standards 2.8.3, 2.8.4, 2.8.5, and 2.8.6 apply only to Atlantic salmon, not cleaner fish.* ⓘ *See Appendix IV for further details on calculating average monthly pen/tank mortality.*							
2.8.1	Each operation must keep a daily mortality record for each pen or tank, and reason for death if known. Mortality records must include if mortalities are observed during handling/management procedures (i.e. during grading, vaccination, etc.).	●		●			●
	ⓘ **[2.8.1 a]:** *Operations are not expected to carry out daily net lifts in order to check for mortalities. However, if mortalities are observed, they must be recorded and dead fish must be removed in accordance with Standards 3.1.2.* ⓘ **[2.8.1 b]:** *This standard requires a daily mortality record for both Atlantic salmon and any cleaner fish species present in the pens.*						
2.8.2	If the average monthly pen/tank mortality exceeds the percentages in 2.8.3-2.8.6, a written intervention plan that addresses, at a minimum, potential cause(s), stocking density, health, environment, and management factors is required to reduce levels in the existing and subsequent pens/tanks (see Appendix II).	●		●			●
Freshwater Production Only							
ⓘ *Freshwater production is defined as the period when salmon are not yet placed in seawater (salinity ≥ 10 ppm).*							
2.8.3	Average monthly pen/tank mortality must not exceed 1.0% during freshwater production.	●		●			
2.8.4	Average monthly pen/tank mortality must not exceed 0.70% during freshwater production.						●
Seawater Production Only							
ⓘ *Seawater production is defined as the time when smolts are placed in seawater (salinity ≥ 10 ppm) until slaughter.* ⓘ*This Section applies to both RAS and open-water sea pens.*							
2.8.5	Average monthly pen/tank mortality must not exceed 0.50% during seawater production.	●		●			
2.8.6	Average monthly pen/tank mortality must not exceed 0.30% during seawater production.						●

3 FISH CARE AND MANAGEMENT

STANDARD		Step Level					
		1	2	3	4	5	5+
3.1 Daily Monitoring							
3.1.1 M	Fish must be observed at least once daily. Records of any health or welfare issues that occur must be kept.	●		●			●
	ⓘ **[3.1.1 a]:** *Observations can be via CCTV, robotic camera systems, windows into tanks, etc.* ⓘ **[3.1.1 b]:** *This standard includes any cleaner fish species being used by the operation.*						
3.1.2	Dead fish must be removed from pens/tanks immediately upon discovery.	●		●			●
	ⓘ **[3.1.2 a]:** *G.A.P. understands that the collection of dead fish during extreme weather events can be challenging and at times, may be impossible. However, collection must resume as soon as weather conditions allow for it.* ⓘ **[3.1.2 b]:** *See Standard 2.8.1 for mortality recording requirements.* ⓘ **[3.1.2 c]:** *This standard includes any cleaner fish species being used by the operation.*						
3.2 Handling ⓘ *G.A.P. understands the need to minimize handling as much as possible however, when fish need to be handled the following Section applies.* ⓘ *In this Section handling standards applies to all fish, including cleaner fish.* ⓘ *See also Section 12.6 (Training) for training requirements for handling.*							
3.2.1 C	Fish must not be mistreated in any way. Mistreatment includes, but is not limited to, kicking, throwing, striking, hitting, deliberately dropping fish, or only holding them by the gills, fins, or tail.	●		●			●
	ⓘ **[3.2.1 a]:** *G.A.P. has a zero-tolerance policy to kicking, throwing, striking, hitting, dropping, or only holding fish by gills or fins and any other actions or omissions in care that could cause harm or injury to salmon or cleaner fish species.* ⓘ **[3.2.1 b]:** *Proper and respectful handling extends to all salmon or cleaner fish species – healthy, sick, injured and/or dead.*						
3.2.2 M	If fish need to be picked up or held, their belly and head must be supported and the fish must be kept horizontal.	●		●			●
3.2.3	If fish are handled out of water for more than 10 seconds, fish must be anesthetized using acceptable anesthetics listed in Standard 2.5.2.	●		●			●
	ⓘ **[3.2.3]:** *See Section 2.5 for requirements regarding anesthesia.*						
3.2.4	The use of knotted nets to handle fish is prohibited.	●		●			●

3.2 Handling *Continued*							
3.2.5	Dry brailing is prohibited.	●		●			●
	ⓘ **[3.2.5]:** *This does not apply to hand nets.*						
3.3 Physical Alterations							
3.3.1	The removal or alteration of skin or tissue is prohibited.	●		●			●
3.3.2	Physical branding or marking is prohibited.	●		●			●
3.3.3	Passive Integrated Transponder (PIT) tags are allowed **only** if the following criteria are met: a. Fish must be anesthetized prior to injection; b. Injection is done via hypodermic needle; and c. The injector must be disinfected between each fish.	●		●			
	ⓘ **[3.3.3 a]:** *PIT tag insertion via surgical implantation is not allowed.* ⓘ **[3.3.3 b]:** *See Section 2.5 for requirements regarding anesthesia.*						
3.3.4	Passive Integrated Transponder (PIT) tags are prohibited.						●
3.4 Crowding ⓘ *Crowding is the process by which fish are brought together into a smaller area so that they can be netted and pumped for the purposes of grading, health checks, transport, treatment, and slaughter.* ⓘ A *crowding event is calculated starting as soon as the tank or pen's volume is reduced and ends when the last fish has been removed from the crowd.* ⓘ *See Appendix V for scoring of a crowd event.*							
3.4.1	Salmon must not be crowded more than 3 times in any 30-day period.	●		●			●
3.4.2	If crowding before transport, crowding must not begin until the transport conveyance has arrived.	●		●			●
3.4.3	An individual pen/tank crowding event must not exceed 2 hours.	●		●			●
	ⓘ **[3.4.3 a]: A** *crowding event is calculated starting as soon as the tank or pen's volume is reduced and ends when the last fish has been removed from the crowd.* ⓘ **[3.4.3 b]:** *G.A.P. understands that in some instances crowding may need to be extended. The operation must provide justification to the auditor which includes the reason for any delay or stop (see Standard 3.4.4).*						

STANDARD		Step Level					
		1	2	3	4	5	5+
3.4 Crowding *Continued*							
3.4.4	Records must be kept of any crowding events that occur during production. These records must include: a. Date; b. Crowd start and end times; c. Crowding score (see Appendix V) for each crowd; d. Oxygen saturation levels; and, e. Reasons for any delays or stops.	●		●			●
	ⓘ **[3.4.4 a]:** *Crowding events are scored by the operation.* ⓘ **[3.4.4 b]:** *The auditor will review the operation's crowding score records and witness a crowd every two (2) certification cycles.*						
3.4.5	Oxygen saturation levels must be maintained at 80% or above during the entire length of the crowd.	●		●			●
3.4.6	An average 12-month crowding score of $\geq$ 2 per pen (see Appendix V) is prohibited.	●		●			●
3.4.7	If an average 12-month crowding score of $\geq$ 2 per pen occurs, (see Appendix V), an intervention plan (see Appendix II) must be implemented to improve subsequent crowds and must address, at a minimum, potential causes of a bad crowd and actions taken to resolve the issue.	●		●			●
3.5 Pumping ⓘ *Process by which salmon are transported from one area to another via pipe, which lifts fish out of the water and transports them to a receiving area. "Pumping" encompasses all pumping systems (i.e. vacuum pump, venturi pump, etc.) used for this purpose.*							
3.5.1	Sick or injured fish must not be pumped. If sick or injured fish are found during the pumping process, they must be removed immediately for treatment, or euthanized in accordance with Section 2.7.	●		●			●
3.5.2	Fish must be observed during pumping.	●		●			●
	ⓘ **[3.5.2]:** *This can be done through the use of observation windows in the pump or cameras placed inside pipes during pumping.*						
3.5.3	Flow rate or pumping speed must ensure that salmon are: a. Not stationary; b. Not able to change direction while in the pipe; and c. Not colliding with one another or the pipe itself.	●		●			●
3.5.4	Water quality must be monitored at the intake and outflow of the pipe throughout pumping.	●		●			●
3.5.5	If water quality at the intake and outflow of the pipe is found to exceed the levels in Standard 5.2.3, a written intervention plan, as detailed in Appendix II, designed to improve water quality during pumping must be implemented by time of the next pumping procedure.	●		●			●
3.5.6	Fish must be monitored at the outflow pump to make sure there are no injuries during pumping.	●		●			●

STANDARD		Step Level					
		1	2	3	4	5	5+
3.5 Pumping *Continued*							
3.5.7	The pipe must be fully flushed at the end of pumping to ensure no fish are left in the pipe.	●		●			●
3.5.8	If the pumping process is stopped for any reason while fish are in the pipe, any remaining fish must be flushed out immediately.	●		●			●
3.5.9	Records must be kept of all pumping events and include at least the following: a. Temperature at the intake and outflow of the pipe; b. Oxygen saturation at the intake and outflow of the pipe; c. Number (if any) of sick or injured fish found during pumping.	●		●			●
3.6 Grading ⓘ*G.A.P. defines grading as the process of size sorting live salmon.*							
3.6.1	Sick or injured fish must not be graded. If sick or injured fish are observed during the grading process, they must be removed and treated, or euthanized in accordance with Section 2.7.	●		●			●
3.6.2	Grading salmon under an average weight of 3g is prohibited.	●		●			●
3.6.3	A passive or active grading system may be used to grade salmon between 3-50g.	●		●			
	ⓘ **[3.6.3]:** *Active grading systems include grading machines or any time salmon must be handled in order to be graded. A passive grading system is one which size-sorts live salmon while they are in water, and does not require them to be handled, such as a flexible grid panel which is placed in the water for fish of a certain size to swim through.*						
3.6.4	Only passive grading systems can be used to grade salmon between 3-50g.						●
3.6.5	Active grading systems are prohibited for salmon greater than 50g (1.76 oz).	●		●			●
3.7 Fin, Skin and Body Condition ⓘ*See Appendix VI for protocols and procedures for fin, skin, and body condition scoring.*							
3.7.1	The operation must have a fin, skin and body condition monitoring program which monitors at least the following during all stages of production (See Appendix VI for Scoring table): a. Skin condition; b. Fin condition (dorsal, pectoral and caudal fins); and c. Body condition.	●		●			●

STANDARD		Step Level					
		1	2	3	4	5	5+
3.7 Fin, Skin and Body Condition *Continued*							
3.7.2	Fin, skin and body condition monitoring and scoring must be conducted weekly on at least 10 fish per pen or tank.	●		●			●
	ⓘ **[3.7.2 a]:** *This monitoring may be conducted via video, AI system, or other technology placed within the pen at the same time as sea lice counts (See Section 8).* ⓘ **[3.7.2 b]:** *See Appendix VI for monitoring and sampling protocol.*						
3.7.3	Fin, skin and body condition monitoring and scoring must be carried out without needing to handle fish or remove them from water.						●
3.7.4	Fin, skin and body condition score per pen/tank must not exceed an annual average of 20.0 (See Appendix VI).	●					
3.7.5	Fin, skin and body condition score per pen/tank must not exceed an annual average of 15.0 (See Appendix VI).			●			
3.7.6	Fin, skin and body condition score per pen/tank must not exceed an annual weekly average of 10.0 (See Appendix VI).						●
3.7.7	Any salmon which receives a fin, skin and body condition score $\geq$ 5 must be euthanized immediately in accordance with Section 2.7.	●		●			●
3.7.8	All fin, skin and body condition scores must be recorded, and records must be kept for at least 18 months	●		●			●
3.7.9	If any weekly fin, skin and body condition scores per pen/tank exceed the threshold written above, a written intervention plan, as detailed in Appendix II, is required to reduce levels for the next sampling event.	●		●			●

4 SMOLITIFICATION

ⓘ *G.A.P. recognizes that the smoltification process (the physiological change salmon undergo to live in full-salinity seawater) can be a particularly vulnerable time so standards for health and conditions for transfer specific for these young salmon are included in this Section.*

ⓘ *For details about transport protocols and procedures for smolts, see Section 11 of this standard.*

ⓘ *For details regarding smolt-specific enrichments, see Standard 5.4.5.*

STANDARD		Step Level					
		1	2	3	4	5	5+
4.1 Smolt Health							
4.1.1 C	The use of hypertonic water to test smoltification status is prohibited.	●		●			●
	ⓘ **[4.1.1 a]:** *Hypertonic water is defined as water with salinity above 35 ppt.* ⓘ **[4.1.1 b]:** *G.A.P. recommends using an ATPase test to determine whether salmon have fully smolted.* ⓘ **[4.1.1 c]:** *If an operation wishes to use a method of smolt testing that is not the ATPase test, written approval from Global Animal Partnership must be received prior to on-farm use in order to meet this Standard.*						
4.2 Seawater Transfer ⓘ *As part of the Fish Health plan detailed in Standard 12.2.1, wave action and current speed at the seawater production site must be assessed prior to smolt placement in marine pens.*							
4.2.1	Feed withdrawal for smolts prior to seawater transfer must not exceed 24 hours.	●		●			●
	ⓘ **[4.2.1]:** *See Standard 11.3.3 for feed withdrawal records.*						
4.3 Smolt Handling							
4.3.1	Newly transferred smolts must not be pumped, crowded or graded for their first 90 days in seawater unless immediate medical intervention or culling is required.			●			●
	ⓘ **[4.3.1]:** *Newly transferred smolts may be sampled weekly for sea lice (Section 8.1) and damage, injury and deformity monitoring (Section 3.7)*						

5 OPEN WATER PENS / TANKS / RACEWAYS

STANDARD		Step Level					
		1	2	3	4	5	5+
5.1 Stocking Density ⓘ *Stocking density is calculated by taking the current biomass of the tank or pen (based on current average weight of all salmon in the tank or pen, excluding any cleaner fish) plus a maximum 3% variation, divided by the estimated volume of the net or tank (from manufacturer's information). For example, if a seawater pen is stocked with 300,000 salmon at an average of 3kg, the current biomass of the pen would be 900,000kg. A net pen that has a 50m diameter and is 30m deep would have a volume of approximately 58,904m^3 (based on the calculation of the volume of a cylinder (Volume = $\pi r^2 h$). To calculate the stocking density, divide 900,000kg by 58,904m^3 to get a stocking density of 15.3kg/m^3, which would qualify for Step 1 or 3 under Standard 5.1.2.* ⓘ *G.A.P. expects the stocking density values listed below to be maintained for the entire life of the salmon.* ⓘ *Seawater stocking density numbers include salmon raised in seawater RAS systems.*							
5.1.1	Salmon stocking density for freshwater production (either in tanks or in open-water pens) must not exceed 45kg/m^3 per pen or tank at any given time.	●		●			●
5.1.2	Salmon stocking density in seawater must not exceed 17kg/m^3 per pen or tank at any given time.	●		●			
5.1.3	Salmon stocking density in seawater must not exceed 10kg/m^3 per pen or tank at any given time.						●
5.2 Water Quality							
5.2.1	For salmon reared in seawater pens, at a minimum, the following must be monitored on a **daily** basis in at least half of the occupied pens on-site: a. Temperature; b. Salinity; c. Oxygen saturation (%).	●		●			●
	ⓘ **[5.2.1]:** *G.A.P. recommends that the operation selects pens to monitor so that all pens are monitored at least once every 2 days.*						

STANDARD		Step Level					
		1	2	3	4	5	5+
5.2 Water Quality *Continued*							
5.2.2	For salmon reared in tanks, at a minimum, the following water quality parameters must be monitored on a **daily basis** for all occupied pens: a. Temperature; b. Oxygen saturation (%); c. CO_2; d. pH. e. Ammonia; f. Nitrate levels; g. Nitrite levels	●		●			●
5.2.3	For salmon reared in tanks, water quality must adhere to the following limits: Minimum Oxygen Saturation: 80% Maximum Free Ammonia: 0.025 mg/L Maximum Carbon Dioxide (CO_2): 15 mg/L pH Range: 6.2-7.8 Maximum Nitrate: 100 mg/L Maximum Nitrite: 0.1 mg/L	●		●			●
5.2.4	If water quality in tanks is outside the levels in Standard 5.2.3, a written intervention plan, as detailed in Appendix II, designed to improve water quality must be implemented within 6 hours.	●		●			●
5.2.5	If oxygen saturation drops below 80%, supplemental oxygen must be provided immediately until oxygen saturation returns to 80% or above.	●		●			●
5.3 Water Temperature							
5.3.1	For salmon reared in tanks, water temperature must remain within 8-16°C (46-60.8°F).	●		●			●
5.3.2	If the salmon farm is situated in waters which experience water temperatures above 16°C for more than 4 consecutive days a year, then the net pens must be at least 18m deep.			●			●

STANDARD		Step Level					
		1	2	3	4	5	5+
5.4 Environmental Enrichment ⓘ *Environmental enrichments are materials that are provided to salmon to add complexity to their environment, encourage the expression of natural behavior(s) (such as hiding, foraging, and exploring) and decrease the expression of abnormal and deleterious behaviors such as fin nipping and cannibalism.* ⓘ *Hatching substrate or water quality are not considered to be enrichments as they are basic requirements of the standard.* ⓘ *Examples of enrichments that qualify for this Section (and those that do not) are shown in Appendix VII.* ⓘ *G.A.P. understands that enrichments are a developing field in salmon aquaculture and is open to novel innovations and ideas from all sectors to determine which enrichments can best enhance salmon welfare. If an operation wants to use an enrichment not listed in Appendix VII, they must reach out to G.A.P. for approval prior to certification.* ⓘ *This Section applies only to salmon; provisions for cleaner fish are outlined in Section 9.2.*							
5.4.1 Ⓜ	Enrichment must be provided by the time fry are ready for first feeding at one (1) month old.	●		●			●
5.4.2	Fry and parr must be provided with at least one (1) Type A enrichment (See Appendix VII) per pen/tank.	●					
5.4.3	Fry and parr must be provided with at least one (1) Type A and one (1) Type B enrichments (See Appendix VII) per pen/tank.			●			
5.4.4	Fry and parr must be provided with at least two (2) Type A and one (1) Type B enrichments (See Appendix VII) per pen/tank.						●
5.4.5	Smolts must be provided with environmental enrichments which alter either the direction or velocity of the current in their pen/tank (See Appendix VII).	●		●			●
5.4.6	Adult salmon must be provided with one (1) Type A enrichment (See Appendix VII) per pen/tank.	●					
5.4.7	Adult salmon must be provided with two (2) types of enrichments (See Appendix VII) per pen/tank.			●			●
5.4.8	Enrichments must be accessible by all salmon in the pen or tank.	●		●			●
5.4.9	Enrichments must be cleaned and maintained to ensure good water quality (when applicable).	●		●			●
5.4.10	Salmon must have continuous access to enrichments.	●		●			●
5.5 Equipment and Hazards Management							
5.5.1	Equipment, nettings, fittings, and protrusions must not injure fish.	●		●			●
5.5.2	All equipment must be cleaned and maintained regularly.	●		●			●

STANDARD		Step Level					
		1	2	3	4	5	5+
5.5 Equipment and Hazards Management *Continued*							
5.5.3	Tanks must be disinfected between re-stocking.	●		●			●
5.5.4	Fish must not come into contact with any potentially toxic substances, such as those used for maintenance, sanitation, and cleaning.	●		●			●
5.6 Net Collapse							
5.6.1	If a net is found to be collapsed, it must be addressed as soon as possible, and at the most, within 12 hours of discovery.	●		●			●
5.6.2	Records must be kept of any incidences of net collapse. Record details must include, but are not limited to: a. date of net collapse; b. reason for net collapse (if known); c. action taken; and d. date and time of action taken.	●		●			●

6 ESCAPES

STANDARD		Step Level					
		1	2	3	4	5	5+
6.1 General Requirements ⓘ *G.A.P. defines an "escape event" as the escape of **any** number of fish from the pen.*							
6.1.1	The operation must have a written protocol on escapes in place, and it must include at least the following: a. an escape prevention plan (e.g. regular net maintenance, alarm systems, etc.); and b. an action plan in the event that an escape occurs (e.g. how the operation will recapture fish and minimize damage. See Section 12.6 Training).	●		●			●
	ⓘ **[6.1.1]:** *G.A.P. understands that incidences of extreme weather or a force majeure such as a tsunami or hurricane may cause delays in implementing remedial action in the event of an escape, but remedial action should proceed as soon as it is safe to do so.*						
6.1.2	Any escape event must be immediately addressed and managed (See Standard 12.2.1).	●		●			●
6.1.3	All escape events (whether actual or suspected) must be recorded, and the record must be kept for a minimum of 18 months. The record must include the following information: a. cause (or suspected cause) of the escape; b. total number of escaped fish (including cleaner fish); and, c. date of escape or date of escape event discovery.	●		●			●

7 FEED

ⓘ *For standards on fasting times prior to transport, please see Section 11.3 – Feed Withdrawal at Transport.*

STANDARD		Step Level					
		1	2	3	4	5	5+
7.1 Feed Regime ⓘ *Section 7.1 applies only to salmon; for cleaner fish feeding requirements, see Section 9.3.*							
7.1.1	Salmon must be fed daily.	●		●			●
	ⓘ **[7.1.1 a]:** *This does not include salmon fry that still have their yolk sac attached, as their nutritional needs are met by the yolk sac until it has been fully absorbed.* ⓘ **[7.1.1 b]:** *In some exceptional circumstances, daily feeding may need to be adjusted, e.g. during algal blooms or incidences of very high temperature. Producers must still adhere to the rest of Section 7 if such adjustment is necessary.*						
7.1.2	Feed must be an of an appropriate size and nutritional content for salmon at all life stages.	●		●			●
7.1.3	Feed must be distributed over at least 75% of the surface of the tank or pen to allow all salmon to access food.	●		●			●
7.2 Feed Hygiene ⓘ *Section 7.2 applies to all feed hygiene, including for cleaner fish feed.*							
7.2.1	Feed in storage bins, feeders and bunkers must not be moldy or mildewed, contaminated by rodents, or otherwise compromised in quality.	●		●			●
7.3 Additives or Ingredients in Feed ⓘ *The requirements in this Section also apply to all cleaner fish feed.*							
7.3.1	The use of insects in feed is prohibited.	●		●			●
	ⓘ **[7.3.1]:** *G.A.P. acknowledges that the use of insect meal in salmon feed is a growing area of interest. However, the use of it as a sustainable, welfare-friendly alternative feed for farmed salmon is still being explored. Until there is a more thorough understanding, the use of insects in feed for Atlantic salmon is not permitted.*						
7.3.2	Salmon by-products in feed are prohibited.	●		●			●
	ⓘ **[7.3.2]:** *This includes whole salmon, parts of salmon, salmon meal, or salmon by-products from the processing industry (e.g. salmon oil).*						
7.3.3	Each operation must keep up-to-date feed ration ingredient lists, or tags, including mineral/vitamin mixes whether using purchased or home mixed feed. Lists and tags need to be made available to the auditor.	●		●			●

STANDARD		Step Level					
		1	2	3	4	5	5+
Mammalian and Avian By-Products in Feed – Recommended (R)							
R1	Use of mammalian and avian by-products in salmon feed is prohibited. ⓘ **[R1 a]:** *By-products include animal waste and products derived from slaughter/harvest process (see glossary).* ⓘ **[R1 b]:** *G.A.P. wants to encourage producers to move away from using mammalian or avian by-products in feed, but recognizes that there are limited alternative options if trying to reduce fish meal and fish oil use, and in addition understands that salmon are a carnivorous species and a completely vegetarian diet would not meet their nutritional needs.*						
7.4 Fish In/Fish Out (FIFO) Ratio ⓘ *The fish in/fish out ratio (FIFO) measures the amount of fish meal and fish oil that is used to produce one weight equivalent of farmed fish (in this case farmed salmon) back to wild fish weight equivalents.* ⓘ *FIFO ratios are only calculated for operations which carry out **seawater production**.* ⓘ *The equation that operations must use to calculate the FIFO ratio is:* **(level of fishmeal in diet (%) + level of fish oil in diet (%))** **(yield of fishmeal from wild fish (%) + yield of fish oil from wild fish (%)) X FCR** *For further details, see Appendix VIII.*							
7.4.1	The average annual FIFO ratio must be recorded.	●		●			●
7.4.2	The average annual FIFO ratio must not exceed 1.5:1 per year class.	●					
7.4.3	The average annual FIFO ratio must not exceed 1:1 per year class.			●			●
7.5 General Feed Withdrawal Requirements							
7.5.1	Feed withdrawal prior to any treatment, vaccination, crowding, pumping or handling event must not exceed 24 hours. ⓘ **[7.5.1]:** *For details regarding feed withdrawal prior to transport see Section 11.3.*	●		●			●

8 SEA LICE

ⓘ *Sea lice are a major threat to salmon health and welfare. The management and treatment of sea lice is an industry-wide challenge, and new technologies and strategies are constantly being developed. G.A.P. recognizes this and seeks to encourage the development of innovative sea lice preventions and treatments that will not cause pain, discomfort or stress in fish.*

ⓘ*G.A.P. recognizes that sea lice are not a risk in RAS seawater production – these systems meet all the requirements of Section 8.*

STANDARD		Step Level					
		1	2	3	4	5	5+
8.1 Monitoring ⓘ *Non-manual counting and monitoring methods, such as video, AI system, or other technology placed within the pen that continually monitor sea lice levels meet the requirements of this section (8.1).* ⓘ *See Section 8.3 for allowed treatment methods if an operation exceeds government-mandated sea lice thresholds.*							
8.1.1 M	Each sea pen must be sampled individually at least once weekly to determine sea lice levels.	●		●			●
8.1.2	A minimum of 10 salmon per pen must be sampled for sea lice counts each week.	●		●			●
8.1.3	A record must be kept of weekly sea lice count values per pen and include the following: a. date of sample; b. number of sea lice per fish; c. if treatment of the pen was necessary; and d. type of treatment used.	●		●			●
	ⓘ **[8.1.3]:** *Only adult female lice are counted to determine weekly sea lice levels. This applies to any species of sea lice.*						
8.1.4	Sea lice counts must be conducted without removing salmon from water.						●
	ⓘ **[8.1.4]:** *This counting may be conducted via video, AI system, or other technology placed within the pen.*						

<table>
<tr><th colspan="2" rowspan="2">STANDARD</th><th colspan="6">Step Level</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>5+</th></tr>
<tr><td colspan="8">8.2 Sea Lice Prevention
ⓘ G.A.P. recognizes that sea lice are one of the largest challenges facing the farmed salmon industry, and that preventative methods are the first step to mitigating sea lice levels.
ⓘ G.A.P. defines a “prevention method” as a proactive method which is planned and implemented prior to reaching any sea lice thresholds.
ⓘ See Appendix IX for further details of sea lice prevention.</td></tr>
<tr><td>8.2.1 M</td><td>Methods of sea lice prevention are listed below, where YES indicates an acceptable method and NO indicates an unacceptable method. See Appendix IX for further details of each method:
<table>
<tr><th>Method of Sea Lice Prevention</th><th>Acceptable?</th></tr>
<tr><td>Submerged pen</td><td>Yes</td></tr>
<tr><td>Snorkel pen</td><td>Yes</td></tr>
<tr><td>Sea Lice Skirt</td><td>Yes</td></tr>
<tr><td>Functional Feed</td><td>Yes</td></tr>
<tr><td>Surface freshwater</td><td>Yes</td></tr>
<tr><td>Parasiticide in Feed</td><td>Yes</td></tr>
<tr><td>Cleaner Fish</td><td>Yes</td></tr>
<tr><td>Ultrasound</td><td>No</td></tr>
</table>
ⓘ [8.2.1]: If an operation wishes to use a sea lice prevention strategy not listed above, they must contact G.A.P. prior to use for approval.</td><td>•</td><td></td><td>•</td><td></td><td></td><td></td></tr>
<tr><td>8.2.2</td><td>Methods of sea lice prevention are listed below, where YES indicates an acceptable method and NO indicates an unacceptable method. See Appendix IX for further details of each method:
<table>
<tr><th>Method of Sea Lice Prevention</th><th>Acceptable?</th></tr>
<tr><td>Submerged pen (with a least weekly access to air)</td><td>Yes</td></tr>
<tr><td>Snorkel pen</td><td>Yes</td></tr>
<tr><td>Sea Lice Skirt</td><td>Yes</td></tr>
<tr><td>Functional Feed</td><td>Yes</td></tr>
<tr><td>Surface freshwater</td><td>Yes</td></tr>
<tr><td>Parasiticide in Feed</td><td>Yes</td></tr>
<tr><td>Cleaner Fish</td><td>No</td></tr>
<tr><td>Ultrasound</td><td>No</td></tr>
</table>
ⓘ [8.2.2]: If an operation wishes to use a sea lice prevention strategy not listed above, they must contact G.A.P. prior to use for approval.</td><td></td><td></td><td></td><td></td><td></td><td>•</td></tr>
</table>

<table>
<tr><th colspan="2" rowspan="2">STANDARD</th><th colspan="6">Step Level</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>5+</th></tr>
<tr><td colspan="8">8.2 Sea Lice Prevention Continued</td></tr>
<tr><td>8.2.3 Ⓜ</td><td>The operation must use at least 1 acceptable lice prevention method at any given time (see Appendix IX for further details on acceptable/unacceptable prevention methods).</td><td>•</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>8.2.4</td><td>The operation must use at least 2 different acceptable lice prevention methods at any given time (see Appendix IX for further details on acceptable/unacceptable prevention methods).</td><td></td><td></td><td>•</td><td></td><td></td><td>•</td></tr>
<tr><td colspan="8">8.3 Sea Lice Treatment
ⓘ G.A.P. recognizes that operations must adhere to specific sea lice levels or thresholds set by their local, state, or federal government. If an operation’s sea lice levels exceed the regulatory threshold and they are required to treat salmon, below is a list of acceptable sea lice treatment methods.
ⓘ Prior to initiating any treatment, operations are expected to use acceptable sea lice prevention method(s) detailed in Standards 8.2.1 and 8.2.2</td></tr>
<tr><td>8.3.1</td><td colspan="7">If salmon need to be treated for sea lice, the operation must use one of the acceptable sea lice treatment methods listed below:
<table>
<tr><th>Method of Sea Lice Treatment</th><th>Acceptable?</th></tr>
<tr><td>Freshwater bath</td><td>Yes</td></tr>
<tr><td>In-pen laser removal</td><td>Yes</td></tr>
<tr><td>Water spray/jets</td><td>Yes</td></tr>
<tr><td>Parasiticide Bath</td><td>Yes</td></tr>
<tr><td>Parasiticide in Feed</td><td>Yes</td></tr>
<tr><td>Hydrogen peroxide</td><td>No</td></tr>
<tr><td>Thermal treatments (water above 20°C/68°F)</td><td>No</td></tr>
<tr><td>Scrubbers</td><td>No</td></tr>
<tr><td>Ultraviolet-C Light</td><td>No</td></tr>
</table>
ⓘ [8.3.1 a]: If an operation wishes to use a sea lice treatment strategy not listed above, they must contact G.A.P. prior to use for approval.
ⓘ [8.3.1 b]: G.A.P. understands that Ultraviolet-C light may be under consideration for future use as a sea lice treatment, but there is no safe dose, and any UV-C exposure is harmful to fish.
ⓘ [8.3.1 c]: See Standard 2.2.2 for record keeping requirements.</td></tr>
</table>

9 CLEANER FISH WELFARE

ⓘ *Cleaner fish are stocked into net pens for the sole purpose of eating/removing sea lice from salmon. This includes species such as lumpfish (*Cyclopterus lumpus*) and various wrasse (*Labrid *sp.). As a different species of fish entirely, their welfare needs and outcomes are separate from that of Atlantic salmon.*

ⓘ *The use of cleaner fish is only allowed at Steps 1 and 3. Operations wishing to achieve Step level 5+ must manage sea lice without the using cleaner fish and therefore the standards in this Section do not apply to Step 5+ operations.*

ⓘ *Certain cleaner fish species don't thrive in all production systems, and we strongly encourage producers to consider oceanographic conditions (including current strength and average wave heights) to determine the best species of cleaner fish to use in their specific production system and location.*

STANDARD		Step Level					
		1	2	3	4	5	5+
9.1 Cleaner Fish Management							
9.1.1 Ⓜ	From June 1, 2022 to June 1, 2024, at least 50% of cleaner fish stocked on farm must be farm-raised. After June 1, 2024, 100% of cleaner fish stocked on farm must be farm-raised.	●		●			
	ⓘ **[9.1.1]:** *G.A.P. recognizes that Step 1 and 3 operations need time to adjust cleaner fish sourcing, due to the location of cleaner fish hatcheries and farms and the challenges of farming cleaner fish at this time. Step 1 and 3 Operations should use the time allotted to make progress toward meeting the cleaner fish sourcing requirements.*						
9.1.2	The number of cleaner fish stocked must not exceed 10% of the population of salmon in the sea pen at any one time.	●		●			
	ⓘ **[9.1.2]:** *This applies to cleaner fish species combined. For example, if there are 100,000 salmon in Pen A, then up to 10,000 cleaner fish may be stocked (equivalent to 10% of the salmon population) in Pen A. If a farm decides to stock both ballan wrasse (*Labris bergylta*) and lumpfish (*Cyclopterus lumpus*) in Pen A, then the operation could put 5,000 lumpfish and 5,000 wrasse into Pen A. The combination of the two cleaner fish species cannot exceed 10,000 total cleaner fish.*						
9.1.3	If cleaner fish experience a disease outbreak or mass mortality event due to disease, they cannot be restocked until the operation has received written confirmation from a vet or fish health professional that restocking is safe and no fish are symptomatic.	●		●			
	ⓘ **[9.1.3]:** *See Section 3.1 for daily monitoring protocols.*						
9.1.4	Cleaner fish may be re-stocked on a per-pen basis a maximum of 2 additional times per salmon production cycle.	●					
	ⓘ **[9.1.4 a]:** *This is 2 times after initial stocking.* ⓘ **[9.1.4 b]:** *This applies to each cleaner fish species separately.* ⓘ **[9.1.4 c]:** *Restocking numbers cannot cause total numbers of cleaner fish to exceed the 10% threshold set in Standard 9.1.2.*						

STANDARD		Step Level					
		1	2	3	4	5	5+
9.1 Cleaner Fish Management *Continued*							
9.1.5	Cleaner fish may be re-stocked once on a per-pen basis per salmon production cycle.			●			
	ⓘ **[9.1.5 a]:** *This applies to each cleaner fish species separately.* ⓘ **[9.1.6 b]:** *Restocking numbers cannot cause total numbers of cleaner fish to exceed the 10% threshold set in Standard 9.1.2.*						
9.1.6	Salmon must be fed immediately before stocking cleaner fish into sea pens.	●		●			
9.1.7	Records must be kept of cleaner fish stocking. These must include, at a minimum: a. Source of cleaner fish stock; b. Date(s) of stocking or re-stocking; c. Date(s) of health screening; d. Number of cleaner fish being stocked or re-stocked; and e. Species of cleaner fish being stocked.	●		●			
9.2 Cleaner Fish Provisions							
9.2.1	Hides or refuges must be provided at all times within sea pens for cleaner fish.	●		●			
	ⓘ **[9.2.1]:** *A hide or refuge for cleaner fish is a structure within the pen which provides an area for cleaner fish to be sheltered and separated from Atlantic salmon.*						
9.2.2	The minimum surface area provided by hides and refuges must be at least 1.0m^2 per 50 cleaner fish.	●		●			
	ⓘ **[9.2.2]:** *For example, if there are 6300 lumpfish deployed in a sea pen, there must be at least 126m^2 of surface area.*						
9.2.3	Cleaner fish must be released next to hides or refuges inside sea pens upon stocking.	●		●			
9.2.4	Hides and refuges for cleaner fish must be located within 1 m of cleaner fish feeding areas within the pen.	●		●			
9.2.5	If using pipes, barrels, or boxes, they must be hollow or provide points of entry so that cleaner fish can hide inside as well as around them.	●		●			
9.2.6	If using artificial kelp as a shelter/hide for cleaner fish, producers must also provide an inflexible hide or refuge such as pipes or barrels.	●		●			

9.3 Cleaner Fish Feed ⓘ *See also Sections 7.2 and 7.3.*							
9.3.1	Supplemental feed for cleaner fish must be provided on a daily basis.	●		●			
9.3.2	Supplemental feed must be delivered in such a way that minimizes competition and allows all cleaner fish to feed.	●		●			
	ⓘ **[9.3.2]:** *The feed delivery method should be species-specific; e.g. lumpfish prefer to eat pelleted feed while wrasse prefer to feed on bait bags suspended throughout the pen.*						
9.4 Cleaner Fish Slaughter							
9.4.1	All cleaner fish must be slaughtered at a G.A.P. Certified slaughter facility.	●		●			
Removing Cleaner Fish at End of Production and Management During Treatment– Recommended (R) ⓘ *G.A.P.'s goal is to set standards in the future for cleaner fish that cover the life of cleaner fish from hatch through to slaughter. However, given the challenges with separating cleaner fish during salmon handling and treatment, setting thresholds for cleaner fish mortality and other challenges, during the launch and implementation of this version of the standard, G.A.P. will collect information and will determine how best to implement these recommendations into the standard for Version 2.*							
R1	At the end of the salmon production cycle, cleaner fish must be removed from the pen and slaughtered prior to salmon being fasted for slaughter.						
R2	Cumulative cleaner fish mortality for a 12-month period must not exceed 10%.						
R3	During pumping, crowding, or in-pen treatment of salmon, cleaner fish must be moved to the opposite end of the sea pen from where the de-lousing equipment/crowding/pumping is located.						
	ⓘ **[R3]:** *This can be achieved by moving cleaner fish hides or shelters or by using sorting equipment.*						

10 PREDATOR AND RODENT CONTROL

STANDARD		Step Level					
		1	2	3	4	5	5+
10.1 Rodent Control Program ⓘ *The standards in this section are applicable to any rodent control efforts, whether contracted or not, in any areas where feed is stored or in indoor grow-out facilities, such as hatcheries.*							
10.1.1	Good sanitation must be the first level of control.	•		•			•
	ⓘ **[10.1.1]:** *Good sanitation includes exclusion of rodents from buildings, bays or bins where feeds are stored; clear up of spills of feed; and management of trash to reduce attracting or harboring rodents.*						
10.1.2	If good sanitation is ineffective, an integrated rodent control program must be implemented. This program must include: a. methods of control that only target rodents; b. an assessment of different methods of lethal control; c. if traps are used, they must be species specific, appropriately located and must be designed to cause rapid death; d. licensed rodenticides are only used in areas where traps will be ineffective (traps are most effective in enclosed spaces and rodent runs.)	•		•			•
	ⓘ **[10.1.2]:** *Glue boards, drowning, and drowning traps do not meet the above requirements.*						
10.2 Predator Control Program ⓘ *Predators include carnivorous marine mammals (seals, dolphins, otters), birds (eagles, herons, gulls), and carnivorous fish (sharks).* ⓘ *If any prohibited predator control method listed in this section is used on any species, whether considered a predator or not, it would be a violation of the Standard.* ⓘ *The standards in this Section are applicable to any predator control efforts, whether contracted or not.* ⓘ *Control of predators must not violate any local, state, provincial, territorial, federal, national, or other laws.* ⓘ *If an operation wishes to use a non-lethal predator deterrent not listed below, they must seek permission from G.A.P. prior to its use on-site.*						
10.2.1	When predators are considered to be a problem, the operation must have a predator control program in place.	•		•			•
10.2.2 Ⓜ	Lethal action against any predator is prohibited.	•		•			•
	ⓘ **[10.2.2]:** *Lethal action includes: poisons, drowning, shooting, or explosives.*						

STANDARD		Step Level					
		1	2	3	4	5	5+
10.2 Predator Control Program *Continued*							
10.2.3 Ⓜ	Non-lethal exclusion of predators from open water nets/pens is the only method of control allowed.	•		•			•
	ⓘ **[10.2.3 a]:** *Non-lethal exclusion methods may include measures such as net tension maintenance, bird netting which covers the top of pens/tanks, or bubble curtains.* ⓘ **[10.2.3 b]:** *In the unlikely event that an animal is caught in an exclusion net, it must be released immediately.*						
10.2.4	Until December 31, 2023, auditory acoustic deterrents (ADDs or AHDs) must adhere to the following conditions: a. They must not emit a signal for more than 10 hours per 24-hour period; and b. They may only be active for an equivalent of 90 days during a 12-month period. **From January 1, 2024, onward, the use of ADDs or AHDs are prohibited.**	•					
	ⓘ **[10.2.4 a]:** *This applies to Step 1 operations only.* ⓘ **[10.2.4 b]:** *ADDs and AHDs have the potential to cause damage to other aquatic species, especially cetaceans (whales and dolphins) and their effectiveness against pinnipeds (seals and sea lions) has not been scientifically proven. G.A.P. recognizes that Step operations may need time to adapt other deterrent methods to meet the prohibition requirements from January 1, 2024 onward. Operations should use the time allotted to make progress towards the complete removal of ADDs or AHDs across all sites.*						
10.2.5	The use of auditory acoustic deterrents (ADDs, AHDs) is prohibited.			•			•
	ⓘ **[10.2.5]:** *This applies to Step 3 and Step 5+ operations only.*						
10.2.6	Dead fish must be disposed of in such a way as to not attract predators to the operation.	•		•			•
	ⓘ **[10.2.6]:** *Fish carcasses or remains must not leak into water bodies during storage or transport off-site.*						
10.2.7	The following predator deterrents are prohibited: a. Snares; b. all traps other than live traps; c. predator nets that are below the surface of the water; d. emetics; e. chasing / pursuit; f. warning shots; and g. floodlights.	•		•			•

11 TRANSPORT

ⓘ *The following transport standards apply to all transport (e.g. truck, boat, helicopter) between operations, holding pens, and slaughter facilities. If an operation uses a mode of transport not covered in this Section, they must reach out to G.A.P. for review.*

ⓘ *If operations do not carry out their own transport, the transport company (or companies) they use must complete G.A.P.'s Transport Personnel Responsibilities, Training and Procedures form. This document must be completed for each certification cycle.*

STANDARD		Step Level					
		1	2	3	4	5	5+
11.1 Handling at Transport							
11.1.1	Acts of abuse and/or egregious acts toward any fish are prohibited. Examples of these behaviors include, but are not limited to, kicking, throwing, striking, hitting, beating, punching, deliberately dropping fish, or holding them only by the gills or fins.	•		•			•
	ⓘ **[11.1.1 a]:** *G.A.P. has a zero-tolerance policy to kicking, throwing, striking, hitting, beating, punching, dropping, or only holding fish by gills or fins and any other actions or omissions in care that could cause harm or injury to salmon or cleaner fish species.* ⓘ **[11.1.1 b]:** *Proper and respectful handling extends to all salmon or cleaner fish – healthy, sick, injured and/or dead.*						
11.1.2	If fish need to be picked up or held, their entire body must be supported.	•		•			•
11.1.3	The use of knotted nets to handle fish is prohibited.	•		•			•
11.1.4	Dry brailing is prohibited.	•		•			•
	ⓘ **[11.1.4]:** *This does not apply to hand nets.*						
11.2 Water Quality During Transport							
11.2.1	The transport vehicle or vessel must have a water quality monitoring system which can: a. Maintain oxygen saturation ≥80%; b. Maintain water temperatures at 8-16°C (46-60.8°F); and c. Alert the transport operator if water quality does not adhere to a. and b. above.	•		•			•
	ⓘ **[11.2.1]:** *See Standard 11.12.1 for details of records that must be kept.*						

STANDARD		Step Level					
		1	2	3	4	5	5+
11.3 Feed Withdrawal at Transport ⓘ *As fish metabolism and appetite is highly dependent on water temperature (e.g. at lower temperatures salmon have a decreased motivation to feed), feed withdrawal time is calculated using degree days rather than in 24hr periods.* ⓘ *Degree days are calculated using the following: Degree Day = $(T_{max} + T_{min})/2 - T_0$, where T_{max} is the maximum daily ambient temperature, T_{min} is the minimum daily ambient temperature, and T_0 is the temperature below which growth and development for salmon is effectively zero (for this calculation, $T_0 = 0°C$). Temperature values must be rounded to the nearest whole number (if a value is less than 1°C, it must be rounded up to 1).*							
11.3.1	Feed must not be withheld for more than 30 degree days prior to transport.	•		•			•
	ⓘ **[11.3.1]:** *G.A.P. understands that incidences of extreme weather or a force majeure such as a tsunami or hurricane may cause delays in transport, potentially leading to longer feed withdrawal duration, but transport should proceed as soon as it is safe to do so.*						
11.3.2	If average sea temperatures are below 5°C (41°F) for 3 days or more, then feed may only be withheld for 15-degree days prior to transport.	•		•			•
	ⓘ **[11.3.2 a]:** *Atlantic salmon's metabolism slows significantly at colder temperatures. However, fish welfare can be negatively impacted if denied feed for an extended period of time, even when at colder temperatures.* ⓘ **[11.3.2 b]:** *G.A.P. understands that incidences of extreme weather or a force majeure such as a tsunami or hurricane may cause delays in transport, potentially leading to longer feed withdrawal duration, but transport should proceed as soon as it is safe to do so.*						
11.3.3	Records of feed withdrawal times must include, at a minimum: a. Date feed withdrawal began and ended; b. Maximum and minimum water temperature values for each day feed was withheld.	•		•			•
11.4 Condition of Salmon at Loading							
11.4.1	Transporting salmon that meet any of the following conditions is prohibited: a. salmon that are sick or injured; b. salmon that score ≥ 5 on the fin, skin and body scoring index (see Appendix VI and Section 3.7); and c. salmon that are not fully smoltified.	•		•			•
11.4.2	If, during the loading process, any salmon are found to meet the conditions of Standard 11.4.1, they must be euthanized in accordance with Section 2.7.	•		•			•

11.5 Transport and Pumping Equipment							
11.5.1	Tanks or wells must always contain water while live fish are still in them.	•		•			•
11.5.2	Equipment used for transport that comes in contact with fish must not contain protrusions, fittings, or other fixtures or attachments which can injure fish.	•		•			•
11.5.3	Once all tanks have been emptied of salmon, all transport water must be disinfected prior to discharge.	•		•			•
11.5.4	Transport operators must be able to visually monitor fish at least every 2 hours during transport.	•		•			•
11.5.5	Wellboats or tanks must be cleaned and disinfected after transporting fish and before loading new fish onboard.	•		•			•
11.5.6	Transport trucks, wellboats, and helicopters, including tanks and monitoring systems, must be in good condition. This includes, but is not limited to: a. Ensuring that all equipment that is used to transport live fish is clean; b. Ensuring that all equipment functions and is operated according to the manufacturer's instructions.	•		•			•
11.5.7	Fish from different facilities or operations cannot be transported together in the same transport unit.	•		•			•
11.6 Transport Duration ⓘ *A transport event is defined as the movement of fish from one location (such as a hatchery or freshwater operation) to another – the destination may be another farm site or slaughter facility.* ⓘ *A transport segment is defined as a portion of a transport event using one type of transport mode (road, sea, or air). Each segment must meet its respective requirements for the type of transport mode used.* ⓘ *Total transport event duration is calculated by adding the duration of each individual transport segment together. For example, smolts may be transported by truck from the hatchery for 10 hours (Segment 1) and then be taken out to open water pens via wellboat for 6 hours (Segment 2), making the total transport event duration 16 hours.* ***a.*** *The time begins when the first fish is pumped onto the transport conveyance at the originating location.* ***b.*** *The time ends when the last fish is unloaded at the receiving location (whether that be another location owned by the farm, another operation, or to the slaughter facility).* ⓘ*Transport duration is assessed based on transport under normal conditions. Unexpected incidences may extend normal transport duration, such as a heavy traffic or accident/weather related delays, and these situations are not included in the calculation.*							
11.6.1	A transport event must not use more than two (2) segments of transport, e.g. land (truck transport) and sea (wellboat transport).	•		•			•

STANDARD		Step Level					
		1	2	3	4	5	5+
11.6 Transport Duration *Continued*							
11.6.2	The total duration of any transport event must not exceed 36 hours.	•					
	ⓘ **[11.6.2 a]:** *A transport event may contain up to two (2) transport segments, but the total combined time in transport cannot exceed 36 hours.* ⓘ **[11.6.2 b]:** *For maximum transport times for air, overland, and wellboat transport see Standards 11.7.2, 11.8.2 and 11.9.4. respectively.*						
11.6.3	The total duration of any transport event must not exceed 24 hours.			•			•
	ⓘ **[11.6.3 a]:** *A transport event may contain up to two (2) transport segments, but the total combined time in transport cannot exceed 24 hours.* ⓘ **[11.6.3 b]:** *For maximum transport times for air, overland, and wellboat transport see Standards 11.7.2, 11.8.2 and 11.9.4. respectively.*						
11.7 Air Transport							
11.7.1	Salmon stocking density in helicopters must not exceed 60kg/m³.	•		•			•
11.7.2	Transport duration of fish by air (e.g. in helicopters) must not exceed 15 minutes.	•		•			•
	ⓘ **[11.7.2]:** *See Standards 11.6.2 and 11.6.3 for total transport event duration limits when multiple transport segments are used.*						
11.8 Overland Transport							
11.8.1	Salmon stocking density in transport tanks on trucks must not exceed 60kg/m³.	•		•			•
11.8.2	Transport duration of fish by land (e.g. on trucks) must not exceed 15 hours.	•		•			•
	ⓘ **[11.8.2 a]:** *G.A.P. understands that incidences of extreme weather or a force majeure such as a tsunami or hurricane may cause delays in transport, but transport should proceed as soon as it is safe to do so.* ⓘ **[11.8.2 b]:** *See Standards 11.6.1 and 11.6.2 for total transport event duration limits when multiple transport segments are used.*						
11.9 Wellboat Transport							
11.9.1	Stocking density in wellboats must not exceed 60kg/m³.	•		•			•
11.9.2	Wellboats must not discharge ballast water within 10 km of an aquaculture site.	•		•			•
11.9.3	Wellboats must not operate with an open-valve system within 10 km of an aquaculture site.	•		•			•

STANDARD		Step Level					
		1	2	3	4	5	5+
11.9 Wellboat Transport *Continued*							
11.9.4	Transport duration of fish in wellboats must not exceed 24 hours.	•		•			•
	ⓘ **[11.9.4 a]:** *G.A.P. understands that incidences of extreme weather or a force majeure such as a tsunami or hurricane may cause delays in transport, but transport should proceed as soon as it is safe to do so.* ⓘ **[11.9.4 b]:** *See Standards 11.6.1 and 11.6.2 for total transport event duration limits when multiple transport segments are used.*						
11.10 Transport Personnel, Responsibilities, and Procedures							
11.10.1	There must be a clear, written procedure, which includes actions and contact numbers, for the driver, pilot, or boat operator to follow in case of an accident or emergency.	•		•			•
11.10.2	The driver, pilot, or boat operator must be knowledgeable in all of his or her responsibilities and transport protocols.	•		•			•
11.10.3	The driver, pilot, or boat operator is responsible for all fish on the truck, helicopter or in the wellboat during transport.	•		•			•
11.11 Training							
11.11.1	All transportation operators must be trained and understand: a. safe pumping procedures; b. potential welfare concerns during transport; and c. the maximum capacity of the transport vehicle or vessel.	•		•			•
11.12 Transport Records							
11.12.1	Transport records must be kept for each vehicle or boat, made available for review, and include: a. date of transport; b. total number of fish transported; c. pumping start and end times for each vehicle, helicopter, or boat transporting salmon to another operation and/or slaughter facility; d. departure and arrival times for each vehicle, helicopter, or boat transporting salmon to another operation and/or slaughter facility; e. water quality values during transport (see Standard 11.2.1); f. reasons for any stops or delays en route; and g. any mortalities during transport.	•		•			•

12 PLANS, PROTOCOLS, PROCEDURES, TRAINING, RECORDS, AND TRACEABILITY

ⓘ *Certain historical records and documents included in this Section may not be available at the time of initial audit as the operation applying for G.A.P. certification was unaware they would be required and, therefore, cannot create them for past events, treatments, assessments, or practices. At the time of initial audit, record-keeping and documentation mechanisms must be in place to meet each of these standards, and records and documentation for, at a minimum, the salmon presently on-site must be available.*

STANDARD		Step Level					
		1	2	3	4	5	5+
12.1 General Records Requirements							
12.1.1	Records must be written (or stored in a computer database) and made available to the auditor and/or certification company. Acceptable formats include but are not limited to; record sheets and cards, calendars, notebooks, and computer documents.	•		•			•
12.1.2	Records must be presented in an organized manner.	•		•			•
12.1.3	All records, reports, Step certificates, and other materials and correspondence relating to Step certificates must be kept for at least one (1) certification cycle.	•		•			•

STANDARD		Step Level					
		1	2	3	4	5	5+
12.2 Written Farm and Fish Health Plan							
12.2.1	Each operation must have a written plan describing: a. an overview of the operation, including size, type/stage of production, location, applicable leases, titles, Area Management Agreements, and typical climatic conditions; b. emergency procedures, including those for natural disasters, escapes, fire, water shut off, net collapse, and, if applicable, power failure; c. operational practices and policies for farmed salmon production: d. provision for daily feed including feeding regime; e. health programs (e.g. supplementation, vaccination and other preventative, maintenance and/or health-promoting practices); f. a written sea lice prevention plan; g. care of sick and/or injured salmon, including on-farm euthanasia policies; h. management of open-water site (if applicable); i. predator control practices; j. environmental management (e.g. escape records, incidences of algal blooms, benthic testing, effluent monitoring, etc.); k. vet recommendations of appropriate current speed and (if applicable) wave action in all tanks/pens regardless of production level; l. a written escape prevention plan.	•		•			•
	ⓘ **[12.2.1]:** *The Farm and Fish Health Plan can be provided by an affiliated group (e.g., a producer group or marketing entity) or created with the aid of external consultation (e.g., veterinarians, peers), but must include information specific and relevant to the operation applying for G.A.P. certification.*						
12.3 Biosecurity Protocols and Procedures							
12.3.1	Each operation must have a documented and implemented biosecurity program that covers, at a minimum: a. procedures for bringing any fish onto the site (including cleaner fish if applicable); b. procedures and policies for employees; c. procedures and policies for visitors to the operations (e.g. minimizing visitors; visitor logs); d. feed trucks and equipment delivery to the operation; e. escape mitigation and recapture procedure and policy; f. minimizing risk of bringing infectious agents into tanks/pens.	•		•			•

12.4 Environmental Sustainability Plan ⓘ *G.A.P. recognizes that both farm animal welfare and sustainability are linked. While our standard focuses on animal welfare, we want to support partner efforts that also take environmental sustainability into account.*							
12.4.1	The operation must have a written plan in place which addresses one or more of the following: a. Effluent and waste reduction; b. Reduction of single-use plastics; c. Increased use of renewable energy sources (e.g. solar, wind); d. Increased use of feeds that source fish meal and fish oil from certified sustainable fisheries; e. Increased use of feeds that source soy from certified non-deforested regions.	•		•			•
	ⓘ **[12.4.1]:** *This standard can be met through a written policy, a third-party sustainability certification, or developed by an external consultant.*						
12.5 Alternative Power Supply							
12.5.1	If power is essential to the operation for water treatment or other support mechanism vital to salmon survival, each operation must have: a. alternative power supply and/or fail-safe device in working condition; b. a method of notification in the event of a power failure.	•		•			•

STANDARD		Step Level					
		1	2	3	4	5	5+
12.6 Training							
12.6.1	Each operation must provide training to all staff and/or managers who are responsible for salmon and cleaner fish (whether full-time, part-time, seasonal or contractual) that: a. is written and/or hands-on; b. is presented in all necessary languages; c. includes instruction on recognizing signs of normal and abnormal salmon and cleaner fish appearance and behavior; d. describes all aspects of the individual's responsibilities; e. describes emergency procedures; f. describes biosecurity protocols; g. reviews a copy of the Written Farm and Fish Health Plan (Standard 12.2.1); h. is provided prior to the individual's handling of any fish on the operation; i. covers all requirements of this version of G.A.P.'s Animal Welfare Certified™ Standards for Farmed Atlantic Salmon; and j. is on-going as necessary and, at a minimum, when any changes affecting the care and management of salmon are implemented.	•		•			•
12.6.2	Each operation must keep a record of staff/manager training (whether full-time, part-time, seasonal or contractual), including dates of training and topics covered (See Standard 12.6.1).	•		•			•
	ⓘ **[12.6.2]:** *Training includes initial, re-training and on-going training.*						
12.7 Traceability and Chain of Custody							
12.7.1	Each operation must have a current G.A.P. Chain of Custody and Traceability for Farmed Atlantic Salmon certification on file.	•		•			•
	ⓘ **[12.7.1]:** *For operations supplying producer groups, it is acceptable for the producer group to record and maintain this information for individual operations.*						
12.7.2	Each operation must have individual stock/year class records that can trace the source of all fish on the operation. Any G.A.P. Certified fish purchased by the operation must also be traceable back to the hatchery.	•		•			•
	ⓘ **[12.7.2]:** *For operations supplying producer groups, it is acceptable for the producer group to record and maintain this information for individual operations.*						

STANDARD		Step Level					
		1	2	3	4	5	5+
12.7 Traceability and Chain of Custody *Continued*							
12.7.3	Each G.A.P. Certified operation must have a chain of custody system with written records. For each shipment of salmon at any life stage transported off the operation, whether to another operation, or to a slaughter facility, the records must include: a. the total number of fish or eggs transported; b. date of transport; c. age of salmon (months); d. G.A.P. Step-level; e. G.A.P. certificate number; f. G.A.P. certificate expiry date; g. if transport is to different locations within an operation, operation-to-operation or operation-to-slaughter facility; and h. any deviations granted including the Standard number and length of approval.	•		•			•
	ⓘ **[12.7.2]:** *Chain of custody can be organized by the individual operation or by an affiliated group (e.g. a producer group or marketing entity).*						

13 SLAUGHTER REQUIREMENTS

ⓘ *See G.A.P.'s Farmed Atlantic Salmon Animal Welfare Slaughter Facility Standard v1.0.*

ⓘ *These Standards in this Section apply to both slaughter at an off-site facility and cage-side harvest.*

STANDARD		Step Level					
		1	2	3	4	5	5+
13.1 General Requirements ⓘ *All requirements of this Section 13.1 apply to both salmon and cleaner fish.*							
13.1.1	Operations must use a G.A.P. Certified slaughter facility to process their salmon.	•		•			•
	ⓘ **[13.1.1]:** *A record must be kept of where the operation sends their fish to slaughter.*						
13.1.2	If an operation uses cleaner fish, they must be slaughtered at a G.A.P. Certified slaughter facility.	•		•			
13.1.3	Salmon must be slaughtered on site, either beside the sea pen or at the RAS facility.						•
	ⓘ **[13.1.3]:** *This applies to Step 5+ only. For open water pens, "on-site" slaughter is on a wellboat, and for RAS or other land-based facilities slaughter must occur within 1 km of the grow-out tanks.*						
13.2 Quality Grading Records at Slaughter							
13.2.1	Operations that send salmon to slaughter must keep quality grading records from each processing event received from the slaughter facility for one (1) certification cycle.	•		•			•
13.2.2	No more than 10% of salmon per 100 sampled can receive a Grade C quality score.	•		•			•
	ⓘ **[13.2.2]:** *See Appendix X for details regarding quality grading and scoring.*						
13.2.3	If quality grading score percentages at each processing event exceed the threshold written above, a written intervention plan, as detailed in Appendix II, is required to reduce levels for the next harvest.	•		•			•

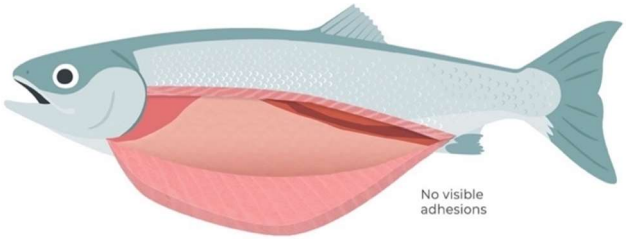
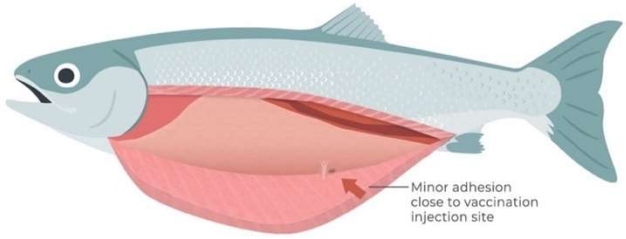
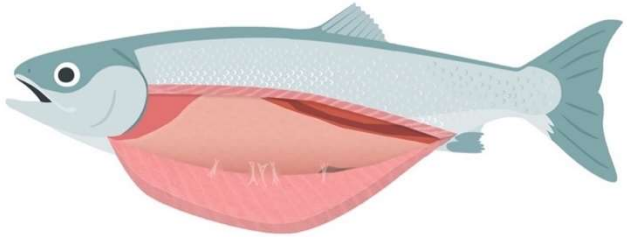
Appendix I: Vaccination Adhesion Scoring

G.A.P. recognizes that incorrect vaccination administration can be detrimental to fish welfare, and that challenges related to vaccination vary across industry. Adhesions are bands of scar-like tissue that form between two surfaces inside the body that are not normally joined together; such as between internal organs or between an internal organ and the body wall. Vaccination adhesions can result from improper vaccine delivery. During the launch and implementation of this version of the standard, G.A.P. will collect information and determine whether additional standards are needed to ensure salmon welfare at vaccination in the future.

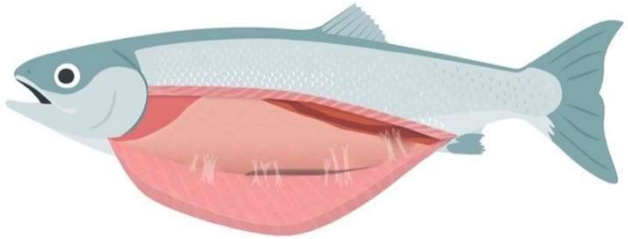
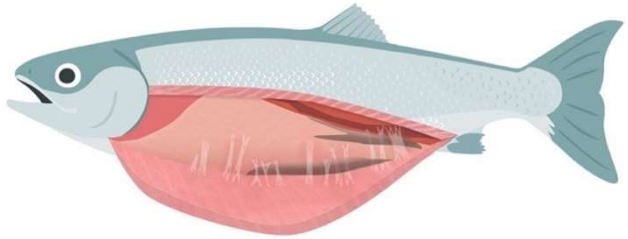
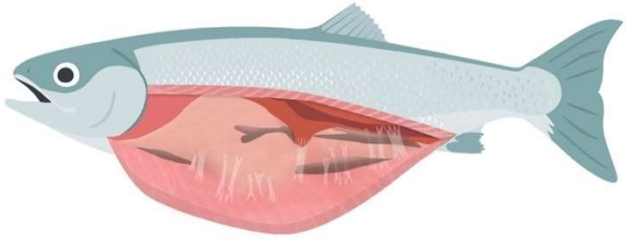
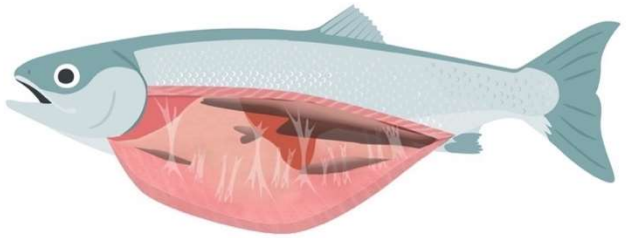
The scale below is used to measure adhesions as a result of vaccination and includes the possible scores a single fish can receive, from '0' – '6'. The scoring protocol should be carried out as follows:

- 30 fish per shipment of fish processed from the operation must be sampled for adhesions at slaughter.
- The slaughter facility selects 30 fish randomly from the shipment and scores each fish once they are dead using the scoring system below.
- The slaughter facility must note the total the number of sampled fish scoring in each category.

Appendix I: Vaccination Adhesion Scoring (cont'd)

Score	Visual Appearance of Abdominal Cavity	Severity of Adhesions
0		None
1		Minor visible adhesions and minor melanisation at site of vaccination.
2		Multiple minor visible adhesions, which may connect colon or spleen to the abdominal wall.

Appendix I: Vaccination Adhesion Scoring (cont'd)

Score	Visual Appearance of Abdominal Cavity	Severity of Adhesions
3		Moderate adhesions, which can be easily removed without causing damage to the fillet. Moderate melanisation at vaccination site.
4		Major adhesions. Moderate lesions which may be hard to remove manually or without causing damage to the fillet. Significant melanisation, not just at vaccination site.
5		Removal of adhesions causes visible damage to the carcass. Extensive adhesions affecting nearly every internal organ in the abdominal cavity. Extensive melanisation and possible hemorrhaging of organs.
6		Major damage to the carcass. Extensive adhesions affecting nearly every internal organ in the abdominal cavity and often with considerable amounts of melanin.

Appendix II: Intervention Plans

Standards 2.8.2, 3.4.7, 3.5.5, 3.7.9, 5.2.4, and 13.2.3 all require written intervention plans to be put into effect if the requirements of the standard are not met. The intervention plan template below must be completed and implemented for each salmon stock when this occurs. G.A.P. Certifiers will review these plans at audit.

Sample Template:

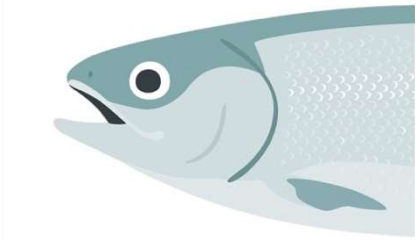
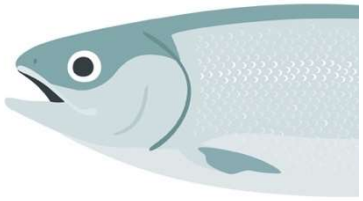
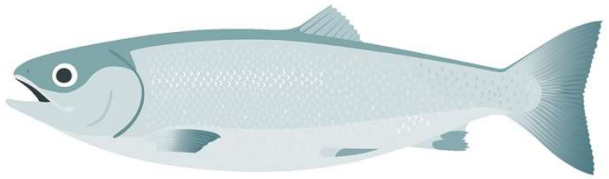
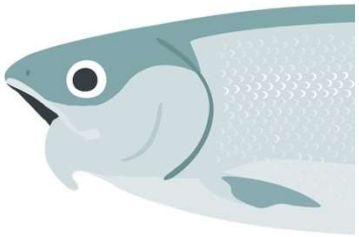
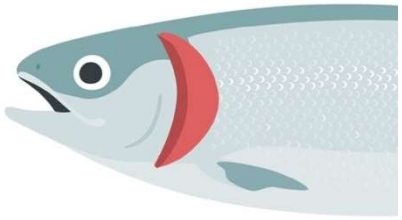
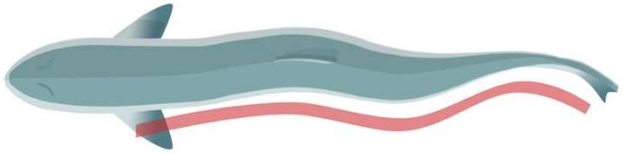
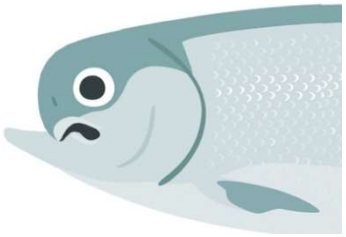
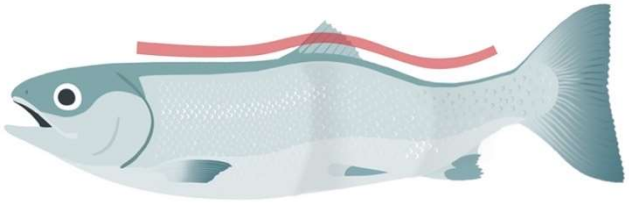
Intervention Plan Questions	**Operation's Response**
Which standard does the pen/tank not meet and what level of damage/injury/mortality/escapes has been found?	
Why has the problem occurred?	
What actions have been put in place to resolve the issue now?	
What actions have been put in place to ensure this does not happen again with future stocks?	

Example of template filled out by operation:

Intervention Plan Questions	**Operation's Response**
Which standard does the pen/tank not meet and what level of damage/injury/mortality/escapes has been found?	*Standard 2.8.4, "Average monthly pen/tank mortality must not exceed 0.70% during freshwater production."*
Why has the problem occurred?	*A fungal infection*
What actions have been put in place to resolve the issue now?	*All affected tanks were drained and disinfected and affected fish were given a dip bath treatment.*
What actions have been put in place to ensure this does not happen again with future stocks?	*a new UV filtration system was installed and tank covers were disinfected and replaced for some tanks (believed they might be harboring the fungus)*

Appendix III: Jaw, Spinal and Opercular Deformities

Standard 2.6.1 sets requirements around culling salmon which display jaw, spinal, or opercular deformities. Below are some examples of salmon with extreme deformities that need to be culled per Standard 2.6.1.

No jaw deformity	No opercular deformity	No spinal deformity
		
Extreme Jaw Deformities	**Extreme Opercular Deformity**	**Extreme Spinal Deformity**
 Lower jaw deformity	 Opercular deformity	 Top View- spinal deformity
 Upper jaw deformity		 Side view- spinal deformity

Appendix IV: Mortality Calculation

Mortality is defined as one of the four following categories:

a) Fish that are found dead through natural causes
b) Fish found dead through predation
c) Fish that are culled
d) Fish that are missing (i.e. escapes)

Though all categories of mortality must be recorded, the percentages used to calculate the mortality thresholds in Standards 2.8.3, 2.8.4, 2.8.5, and 2.8.6, include **only** salmon that die of natural causes, are predated upon, and culled; points (a), (b) and (c) above.
Cleaner fish are not included in this calculation and losses due to escapes are not included either.

Average Monthly Pen Mortality % = [((# salmon died per month + # salmon culled per month) / total # of salmon in-pens or tanks) x 100]

EXAMPLE:

Pen #	# salmon in pen/tank	# of culls*	# salmon that died (natural causes and predation)
1	100,000	200	150
2	90,000	300	200
3	95,000	250	100
4	100,000	150	200
5	100,000	100	150
6	90,000	100	100
7	95,000	250	100
8	100,000	100	200
9	100,000	200	150
10	95,000	150	200
11	90,000	350	100
12	95,000	200	150
Total	1,150,000	2,350	1,800

*culls includes animals that have been euthanized as a management decision.

CALCULATION: [(2,350 + 1,800) / 1,100,000] *100
Average monthly pen mortality % (2dp): .38%

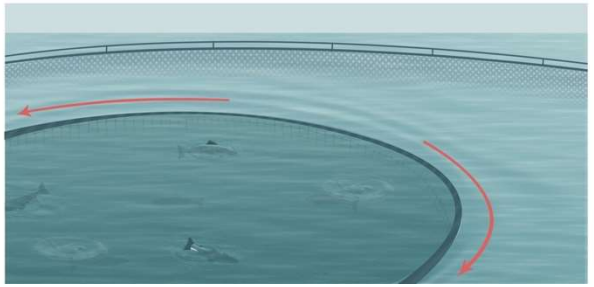
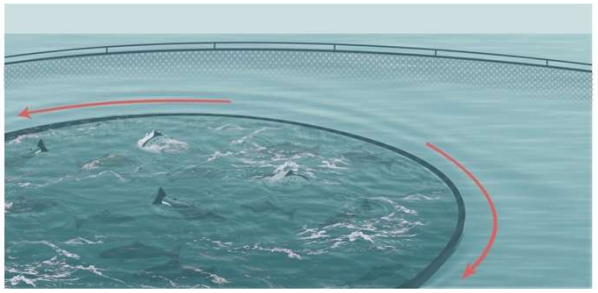
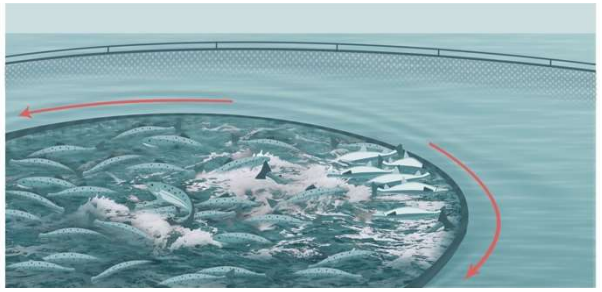
Standard 2.8.5 for Steps 1 & 3 permits .50% average monthly pen mortality during marine production, so in this example, the operation meets the standard for Steps 1 or 3.

Appendix V: Crowding Score

At every crowding event, the scoring system below is to be used to assess the calmness of the fish during handling or crowding events (see Standard 3.4.6. A crowding event is calculated starting as soon as the tank or pen's volume is reduced and ends when the last fish has been removed from the crowd. Scoring is conducted as soon as the net is pulled in to create the crowd.
Each crowding event will receive a score. The highest score that is observed during the whole event is recorded. No half scores are permitted – if the observer is between two scores, the higher score is selected.

The auditor will review the operation's crowding score records and witness a crowd every two (2) certification cycles.

Appendix V: Crowding Score (cont'd)

Score	Description	Sample Picture
0	Calm: Water surface smooth, no vigorous activity, occasionally fins break surface of water.	
1	Restless: occasional splashing, fins and parts of fish above water, choppy water.	
2	Agitated: Churning water, fins and parts of fish above water, burrowing, gasping, and flashing. Some fish may be entangled or stranded on parts of the net that are not in water. **Occurs for more than 1 minute**.	

Appendix VI: Fin, Skin, and Body Condition

Standard 3.7.2 requires a fin, skin and body condition monitoring program to be carried out on a weekly basis. Section 2.6 provides details regarding culling emaciated salmon. Section 3.7 sets limits for skin condition (wounds/ulcers), fin condition, and body condition (emaciation state).

The scoring protocol should be carried out as follows:

- 10 fish per pen or tank each week must be sampled for damage or injury to the fin, skin and body.
- The operation selects 10 fish randomly from the pen/tank and scores each fish using the scoring system below.
- Each fish will receive a score for any type of damage or injury.
- The scores for each type of damage or injury will be totaled for each individual salmon.

For fin damage, the assessor must look at the pectoral, dorsal, and caudal fins and assign a score based on the **most damaged fin**. For example, Salmon A could score a 1 for its dorsal fin, a 1 for its caudal fin and a 2 for its pectoral fins. The assessor would give Salmon A an overall score of '2' by taking the most damaged fin score.

- The weekly average for the pen/tank is the sum of the scores for the 10 salmon assessed.
- An annual average score is calculated for each pen/tank from the weekly averages (sum of the weekly pen/tank average divided by the number of weeks the pen/tank was occupied and rounded to the nearest whole number)

Appendix VI: Fin, Skin, and Body Condition (cont'd)

Calculating the pen's Total Fin, Skin and Body Condition Sum Weekly:
Each individual salmon's point total added together = Total Fin, Skin and Body Condition Sum

For example:
In Pen 1, 10 salmon are sampled:

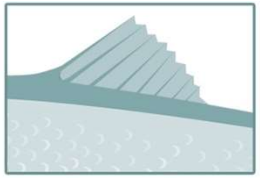
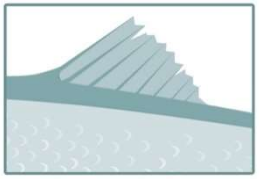
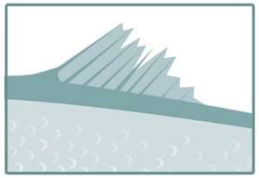
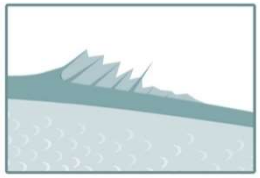
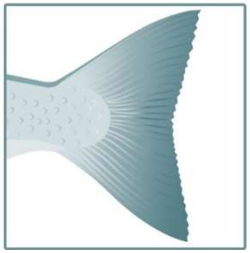
Salmon #	Wound/Ulcer Score	Fin Damage Score	Emaciation Score	Total Score
1	0	2	0	2
2	1	2	0	3
3	1	1	0	2
4	0	0	1	1
5	2	1	0	3
6	1	1	1	3
7	1	2	0	3
8	2	1	2	5
9	3	1	0	4
10	0	1	0	1
Pen Total				**27**

For Pen 1, the total injury and damage sum is 27 (out of a possible maximum of 90 points).

To calculate the annual weekly average of scores per pen from the past 12 months, add each weekly score and divide the sum by the number of weeks the pen was occupied and round to the nearest whole number.
For example, the total sum of weekly scores from the past 12 months for Pen A is 850. It was occupied for 45 weeks 850/45 = 18.8.
The annual fin, skin and body condition score for Pen A is 19 and is in compliance with Step 1.

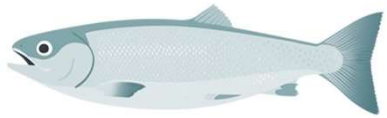
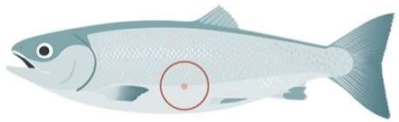
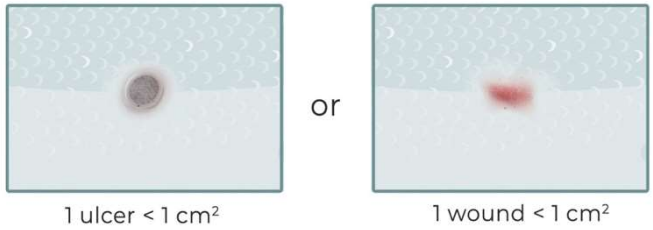
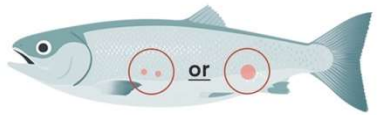
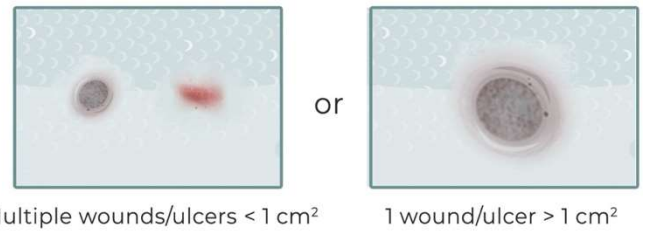
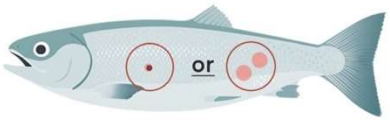
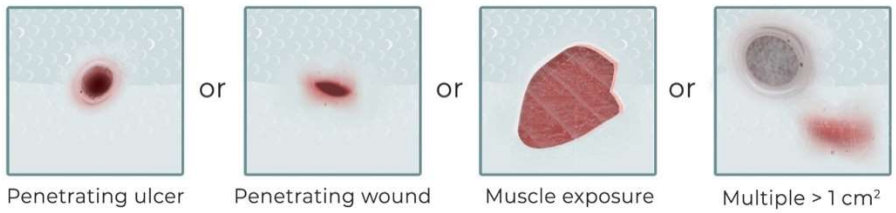
Appendix VI: Fin, Skin, and Body Condition (cont'd)

Fin Condition (pectoral, dorsal, caudal)

	0 Points Fin is completely intact with no splits.	**1 Point** 1-2 splits no longer than .5 cm (5 mm) in length or most or all of fin present	**2 Points** More than 1-2 splits no longer than .5 cm (5 mm) in length or any splits exceeding .5 cm (5mm) in length or 1 exposed fin ray.	**3 Points** Very little of the fin remaining or multiple exposed fin rays or necrosis and bleeding .
				
				
				

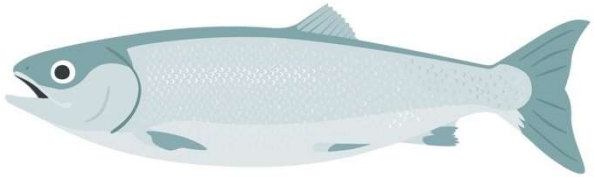
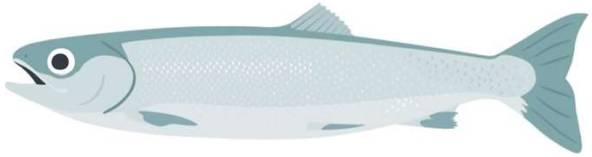
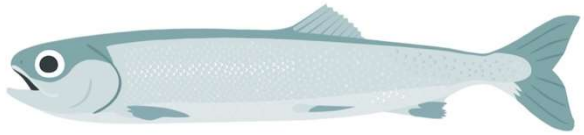
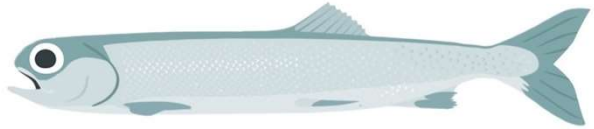
Appendix VI: Fin, Skin, and Body Condition (cont'd)

Skin Condition

0 Points		No wounds, ulcers or other skin injuries.	
1 Point		1 superficial wound or ulcer < 1 cm^2	
2 Points		Multiple superficial wounds or ulcers or 1 superficial wound/ulcer >1 cm^2	
3 Points		A penetrating wound, ulcer, or muscle exposure or multiple wounds/ulcers >1 cm^2	

Appendix VI: Fin, Skin, and Body Condition (cont'd)

Emaciation Status

0 Points Not emaciated.	
1 Point Potentially emaciated, leaner around the stomach and not as rounded.	
2 Points Emaciated, obviously thin, smaller in size.	
3 Points Extremely emaciated, very thin or stunted growth, small.	

Appendix VII: Environmental Enrichments

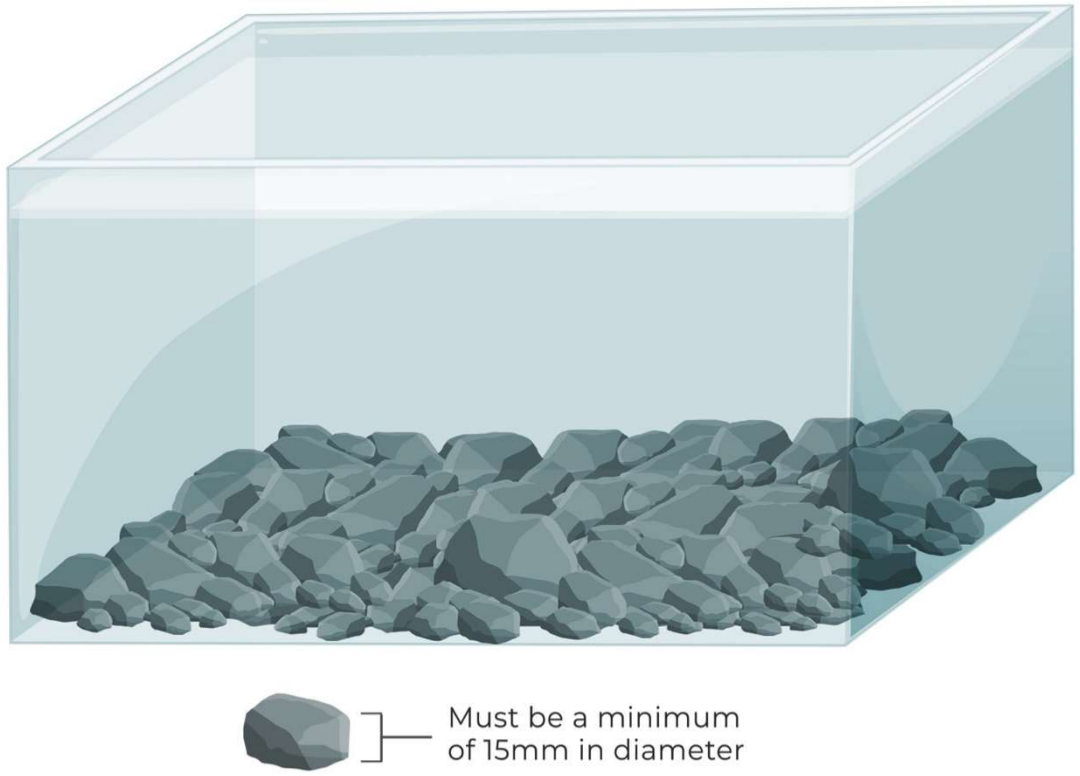
Section 5.4 Environmental Enrichment requires salmon at different life stages to be provided with enrichment. Farmed salmon benefit from a rich environment that is stimulating and allows them to express their natural behavior. Enrichments are an addition to the salmon's environment that encourages the expression of natural behaviors such as hiding, foraging and exploring, and decrease the expression of deleterious behaviors such as fin nipping and cannibalism. Hatching substrate or water quality are not considered to be enrichments as they are basic requirements of the standard.

The aim of an enrichment is to:
1. Add stimuli and long-term novelty to the salmon's environment;
2. evoke- and maintain- their interest, and;
3. improve their physical, behavioral, and/or mental well-being.

Enrichments can benefit salmon raised in any setting, whether exclusively on land in tanks or in open-water pens. By introducing these interactive elements, the lives of salmon can be enhanced. However, not all enrichments are the same in terms of how well they actually "enrich" the salmon's environment.

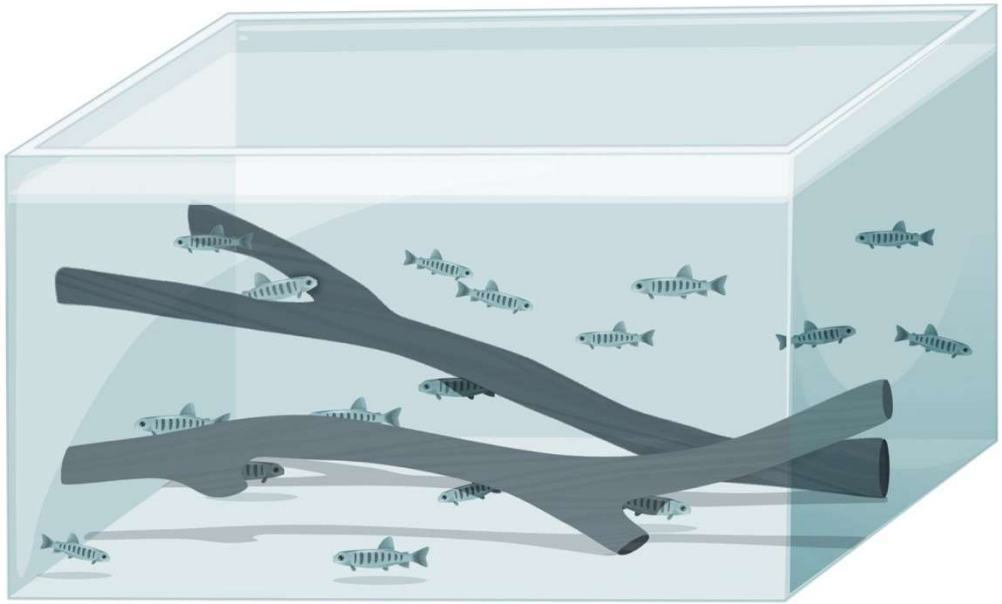
The tables below list enrichments that count towards the requirements of the Section Environmental Enrichment and those that do not and are by no means exhaustive. The examples and discussion on why, or why not they are enrichments that count towards the requirements of Section 5.4 are intended to help understand what provisions are most meaningful to salmon.

The Acceptable Enrichments below may be more applicable at certain life stages. It is for the operation to determine which enrichment best fits their production type and salmon life stage. If an operation would like to use an enrichment not listed below, written approval from Global Animal Partnership must be received prior to on-farm use in order to meet this Standard.

ENRICHMENTS THAT DO MEET THE REQUIREMENTS OF SECTION 5.3: TYPE A	
Substrate 	**What is the product?** Rocks, pebbles, stones. **What are the criteria for acceptable use:** Substrate used must be a minimum of 15mm (0.6 inch) in diameter and the entire bottom of the tank must be covered. **Why is it an enrichment?** Juvenile salmon in the wild live in streams with a rocky substrate. While there may be some finer sands or pebbles, providing pebbles or rocks greater than 15mm in diameter allows for greater oxygen flow through the substrate and decreases the chances of smaller fish becoming trapped or suffocating in the substrate.

ENRICHMENTS THAT DO MEET THE REQUIREMENTS OF SECTION 5.3: TYPE A

Visual Barrier

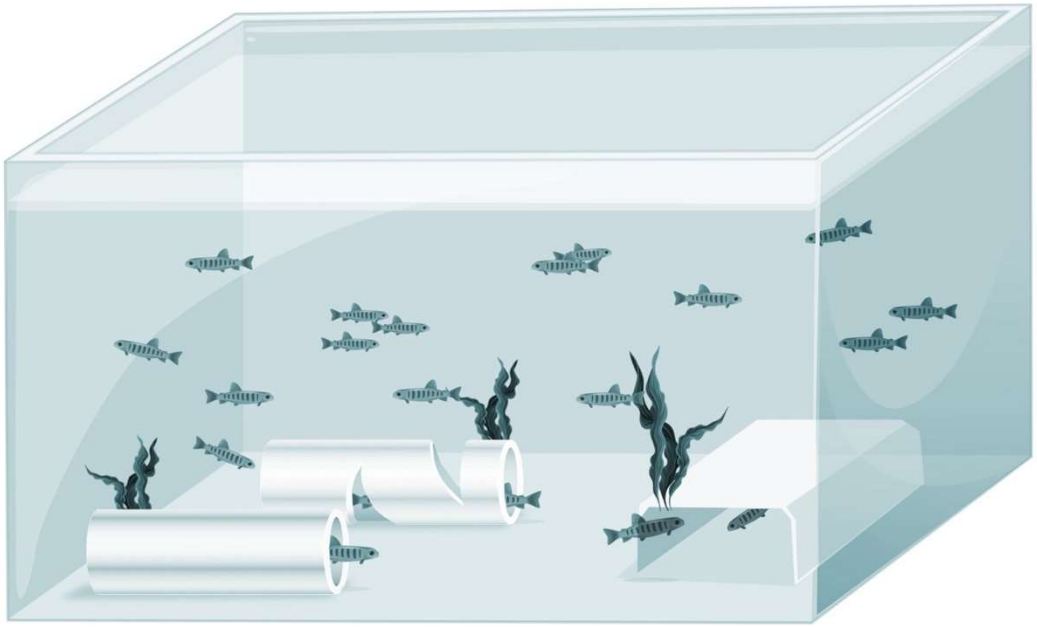


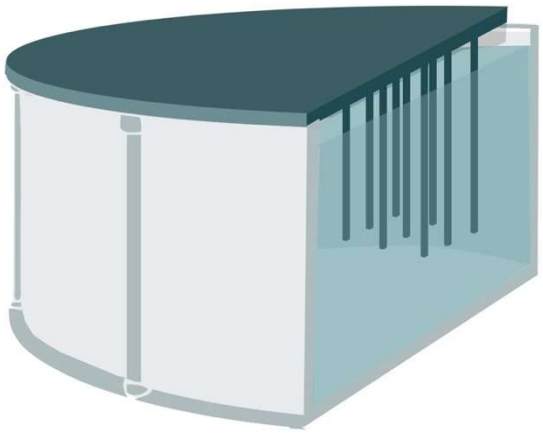
What is the product? Visual barriers are structures which allow multiple salmon to shelter beneath or around them, e.g. branches, logs, or untreated wooden planks.

What are the criteria for acceptable use:

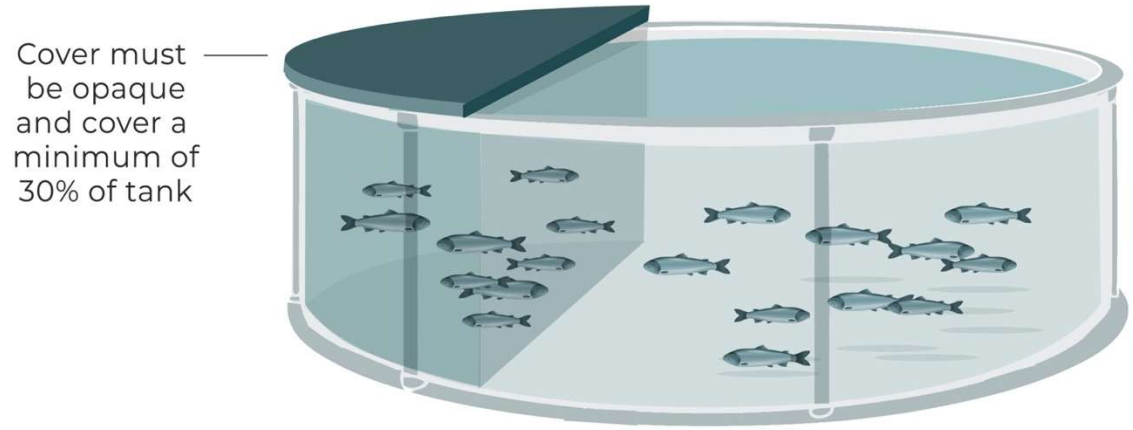
- Visual barriers **used during freshwater grow-out** must be at minimum 60 cm (24 inches) in length and 4 cm (1.5 inches) in diameter/width.
- Visual barriers **used during seawater grow-out** must be at minimum 2m (6ft) in length and 6.4 cm (2.5 inches) in diameter/width
- Any materials used to create the barriers must not contain or be treated with chemicals or substances which may be poisonous to fish or humans.

Why is it an enrichment? Rivers and streams provide myriad ways for juvenile salmon to perform hiding behaviors, not only to escape predators but also to escape aggression from other salmon.

ENRICHMENTS THAT DO MEET THE REQUIREMENTS OF SECTION 5.3: TYPE A	
Submerged hides **(only for freshwater production)** 	**What is the product? For freshwater production only.** Structures such as plastic pipes or boxes which are open at one or both ends and allow fish to swim or hide within them. **What are the criteria for acceptable use:** -PVC pipes at least 15 cm (6 inches) long with a diameter of at least 9 cm (3.5 inches). - Plastic boxes which are at least 25 cm (10 inches) long, 20 cm (8 inches) wide and 15 cm (6 inches) tall. **Why is it an enrichment?** Rivers and streams provide myriad ways for juvenile salmon to perform hiding behaviors, not only to escape predators but also aggression from other salmon. Studies have shown that even if shelter is not appearing to be utilized, its presence provides a less stressful environment because juveniles know they can hide or get away quickly if need be.

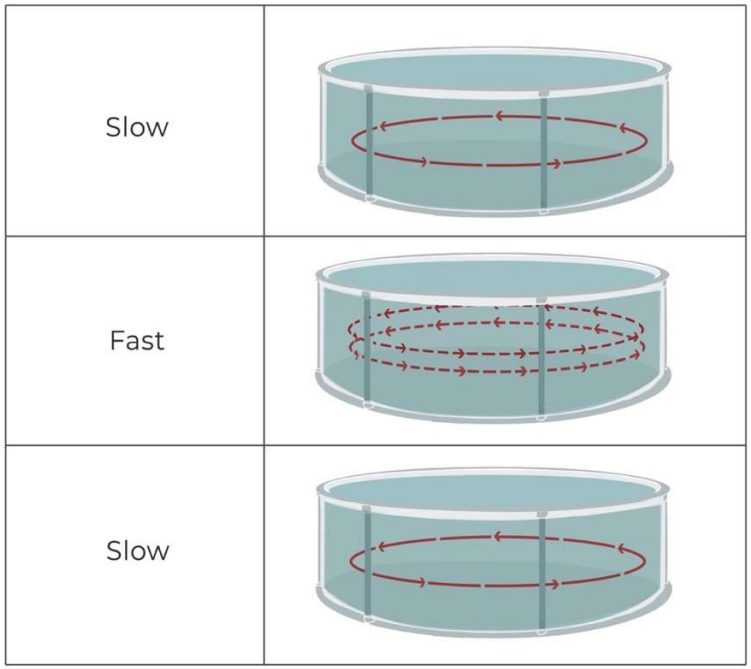
ENRICHMENTS THAT DO MEET THE REQUIREMENTS OF SECTION 5.3: TYPE A	
Hanging curtain  	**What is the product?** A row or string of hanging ropes, rods or kelp which creates a “curtain”. **What are the criteria for acceptable use:** - The "curtain" must be comprised of at least 5 hanging ropes or rods which are fully submerged. They may also be anchored to the bottom of the tank or pen. - For freshwater only: Rods, ropes or kelp must be at least 2.5 cm (1 inch) in diameter. - For seawater only: Rods, ropes or kelp must be at least 8 cm (3 inches) in diameter. - The minimum length of the rods, ropes or kelp must be equivalent to 50% of the depth of the tank or pen. For example, if the tank is 2m deep, the curtain would need to be at least 1m long. **Why is it an enrichment?** Salmon come across a variety of environments throughout their entire life cycle. The purpose of the hanging curtain is to disrupt the flow of current, create a novel area to explore, provide a visual barrier and an area where salmon can hide or escape aggression.

ENRICHMENTS THAT DO MEET THE REQUIREMENTS OF SECTION 5.3: TYPE A	
Moving Light Array **no illustration**	**What is the product?** Submerged lights within the tank or pen which turn on and off. **What are the criteria for acceptable use:** - The light must be green-emitting (520-525 nm) - The light beam must move or have the effect of moving (the lights must turn on and off sequentially in one direction to create the effect of movement, either clockwise or counterclockwise). Lights which flash on and off randomly will not count toward this standard. **Why is it an enrichment?** Exercise is highly beneficial to salmon growth, development, and feed conversion. Salmon respond to the movement of light and studies have shown that light stimulus can prompt salmon to perform sustained swimming at their critical swimming speed. In addition, moving lights also mimic prey behavior and can invoke a prey chasing response in salmon.

ENRICHMENTS THAT DO MEET THE REQUIREMENTS OF SECTION 5.3: TYPE B	
Overhanging or over tank/pen cover 	**What is the product:** A covering or overhanging structure above the pen or tank. **What are the criteria for acceptable use:** -must cover at least 30% of tank. -The "cover" provided by the overhanging material must offer physical barrier from light. For example, an opaque cover such as solid canvas cover. - The overhanging material must not harm fish in the event that a leaping fish comes into contact with it. **Why is it an enrichment:** Rivers and streams provide myriad ways for juvenile salmon to perform hiding behaviors, not only to escape predators but also aggression from other salmon. Studies have shown that juvenile salmon in tanks will utilize shelter and, in its absence, seek out less-exposed areas of barren tanks. An overhang allows larger amounts of fish to utilize the hiding space or shaded area.

ENRICHMENTS THAT DO MEET THE REQUIREMENTS OF SECTION 5.3: TYPE B

Alternating water current velocity
(only for freshwater production)



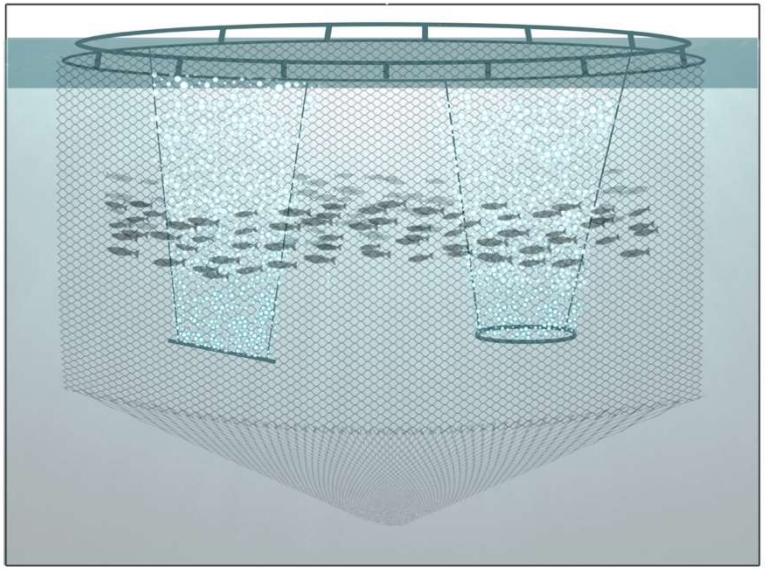
What is the product: A system by which the water current velocity is able to be adjusted to various speeds.

What are the criteria for acceptable use: For freshwater production only. The current speed must be changed at least 3 times weekly. The direction may also be changed but only changing the direction of the current does not count as an acceptable enrichment.

Why is it an enrichment: Wild parr and smolts will choose to move with stronger currents within the stream but may also seek shelter or rest in slower-moving current areas. By varying when current velocity changes, juvenile salmon can be better equipped to deal with post-smolt transfer to seawater.

ENRICHMENTS THAT DO MEET THE REQUIREMENTS OF SECTION 5.3: TYPE B

Bubble Curtain



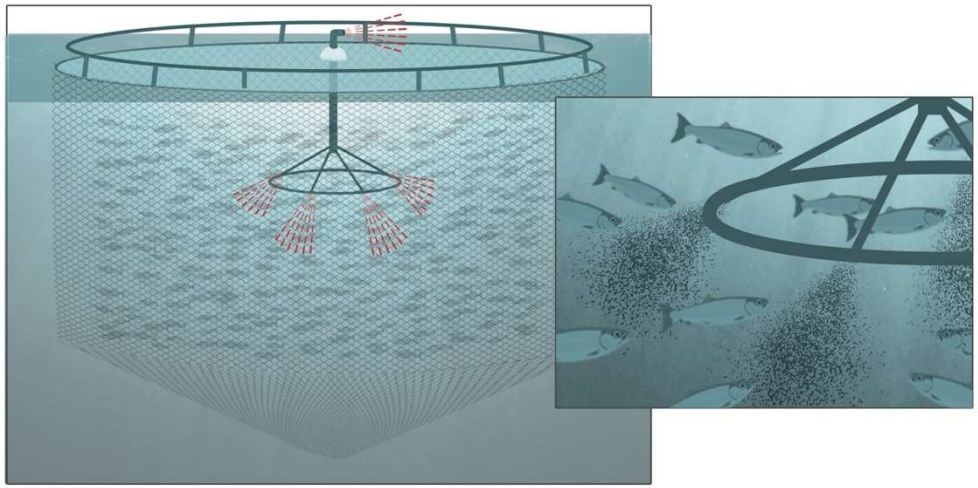
What is the product: A bubble curtain or ring inside of the pen or tank.

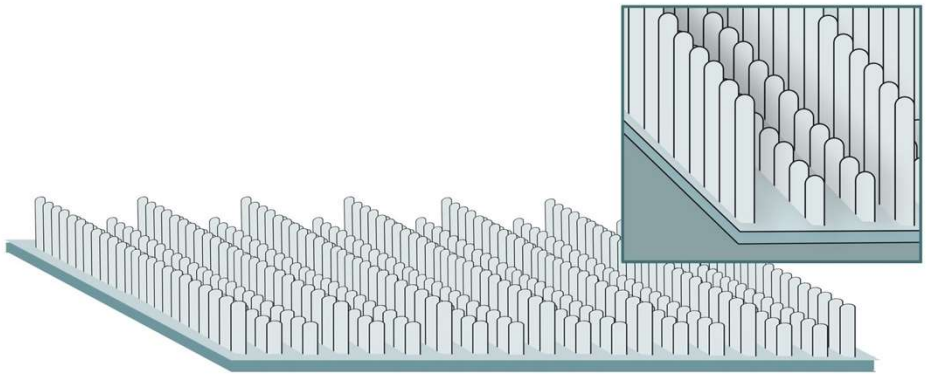
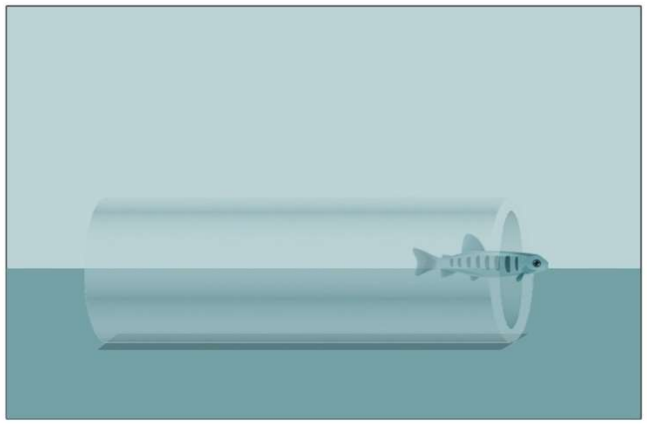
What are the criteria for acceptable use:

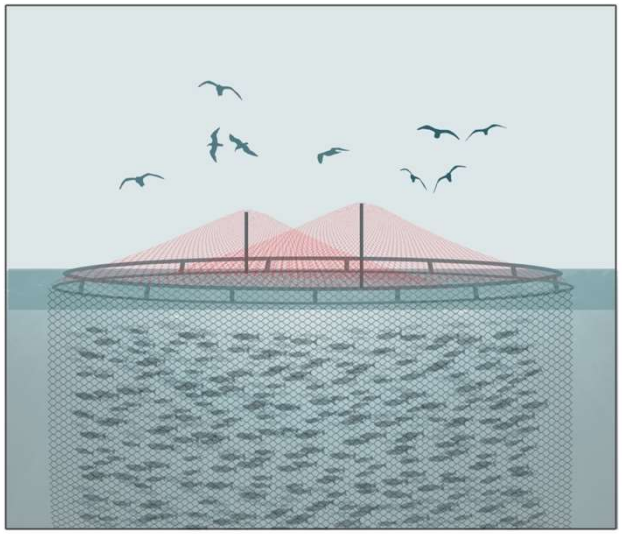
- Bubbles must flow upward for at least ¾ of the depth of the pen or tank. For example, if a pen is 18m deep, then the source of the bubbles would be placed at least 13.5m deep.
- The shape of the bubbler can be either in a ring or a straight line (creating a "curtain" effect)
- If using a ring shape, the diameter must be at least 1m
- If using a straight line, the line must be at least 1m long

Why is it an enrichment:

Bubble curtains provide both a visual barrier and a constantly changing, moving aspect to the salmon's environment. Salmon can interact with the bubbles at different points and because the bubbles are constantly changing as they interact with the pen/tank environment, they maintain their novelty for salmon.

ENRICHMENTS THAT DO MEET THE REQUIREMENTS OF SECTION 5.3: TYPE B	
Simultaneous feed distributed at different depths (only for marine production) 	**What is the product:** Feed which is appropriate to a salmon's life stage and is distributed throughout the water column. **What are the criteria for acceptable use: For seawater production only.** Feed must be released at varied points throughout the water column **at the same time**. Feed which is released at the surface and sinks does not count towards fulfilling this enrichment. The feed must be released in a way that large numbers of salmon can access the feed at the same time. **Why is it an enrichment:** Wild salmon feed and forage throughout the water column. When feed only comes from the surface, it also has the potential to cause salmon competition and aggression, and less dominant individuals are unable to feed. Feeding simultaneously at different depths gives all salmon a better chance of receiving food.

ENRICHMENTS THAT DO NOT MEET THE REQUIREMENTS OF SECTION 5.3	
Hatching Mats/hatching substrate 	**What is it:** A screen, grid, artificial turf or similar which is used for hatching so that once hatched, alevins may swim below or through it and rest upon substrate. **Why isn't it suitable as an enrichment:** Hatching mats may be used as part of egg and alevin production as part of the 5-Step® standards but do not count towards enrichment requirements.
Transparent shelter or hides 	**What is it:** Tank or pen covers, overhangs or shelters which are transparent. **Why isn't it suitable as an enrichment:** The purpose of hides, shelters, and covers are to break up the visual field and shield salmon. While transparent plastic may distort the underwater visual field slightly, it does not provide sufficient shelter or shade to ensure salmon are hidden if they choose to be.

ENRICHMENTS THAT DO NOT MEET THE REQUIREMENTS OF SECTION 5.3	
Predator Nets 	**What is it:** Netting over tanks or pens with the sole purpose of deterring predators. **Why isn't it suitable as an enrichment:** Predator deterrent nets over the tanks or pens do not provide areas of shade or darkness where salmon can hide or shelter. Predator netting may be used as a non-lethal deterrent as part of the 5-Step® standards but does not count towards enrichment requirements.
Tank wall coloring **no illustration**	**What is it:** Painting or otherwise coloring the walls of salmon tanks a color besides white **Why isn't it suitable as an enrichment:** Coloring tank walls does not fall within G.A.P.'s definition of enrichment. Because it is flat and not a three-dimensional addition to their environment, they cannot hide or forage within it. Producers may use colored tank walls, but doing so does not meet G.A.P.'s enrichment requirements.

APPENDIX VIII: Fish In/Fish Out (FIFO) Calculation

Calculating an operation's FIFO ratio can provide important insight into how feed inputs are a part of an operation's overall sustainability efforts. The use of wild fish for aquaculture feed should be minimized whenever possible, and G.A.P. supports the use of fishery trimmings and by-products (except for salmon by-products per Standard 7.3.2), as well as novel feed ingredients such as algal oil which may help an operation reduce its FIFO ratio.

Fishery by-products such as trimmings or other aquaculture by-products (as long as those by-products do not include salmon by-products as stated in Standard 7.3.2) do **not** count in FIFO calculations. The FIFO ratio is strictly meant to be a measure of an operation's use of materials from reduction fisheries (fisheries that target species specifically to "reduce" or process them into fish meal and fish oil).

The FIFO ratio can be calculated as follows (to 1 decimal place):

First, the operation needs to calculate the Feed Conversion Ratio (FCR) for each year class.

FCR = Total annual feed used (mt) / (total harvested fish weight (mt) – smolt weight (mt))

Using the FCR, the operation can then calculate the FIFO ratio:

$$\text{FIFO} = \frac{(\text{level of fishmeal in diet (\%)} + \text{level of fish oil in diet (\%)})}{(\text{yield of fishmeal from wild fish 22.5\%*}) + \text{yield of fish oil from wild fish 5\%*}))} \times \text{FCR}$$

**The values for yield of fishmeal and fish oil from wild fish determined by values from MarinTrust, which are recognized as the industry standard. Further information can be found here: https://www.iffo.com/system/files/downloads/EAS%20FIFO%20September2009%202_0.pdf*

Sample calculation:
An operation uses salmon feed which contains 15% fishmeal and 10% fish oil. The yield of fishmeal from wild fish is 22.5% and fish oil is 5%. The operation uses 350 mt of feed annually and harvests 400 mt of salmon (smolt weight of 48 mt). The Feed Conversion Ratio would be calculated as follows:

FCR = 350 / (400-48)
FCR = 350 / 352
FCR = .99

APPENDIX VIII: Fish In/Fish Out (FIFO) Calculation (cont'd)

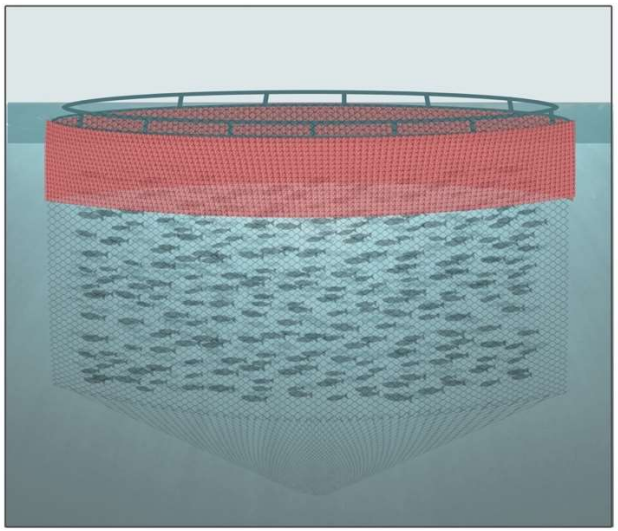
For a Feed Conversion Ratio of .99, the FIFO would be calculated as follows:

FIFO = (15% + 10%) / (22.5% + 5%) X .99
FIFO = (25%)/(27.5%) X .99
FIFO = .9 X .99
FIFO = .9

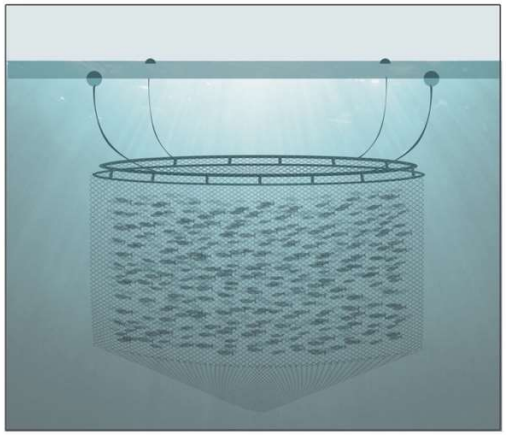
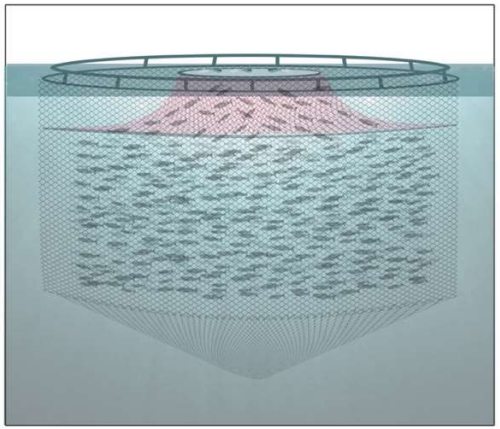
For this example, the operation would be in compliance at Step 3 or 5+.

APPENDIX IX: Sea Lice Prevention Methods

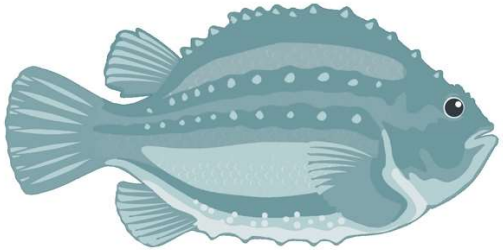
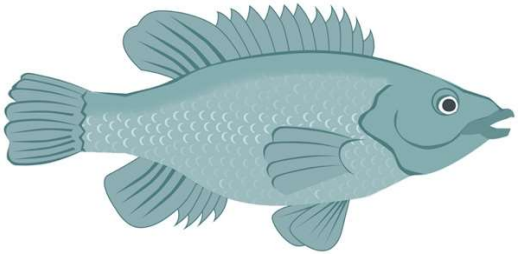
Methods of sea lice prevention are listed below, where YES indicates an acceptable method and NO indicates an unacceptable method.

Lice Prevention Methods	Description	Acceptable?
Lice skirts	A very fine or impenetrable covering around the outside of the pen. 	Yes

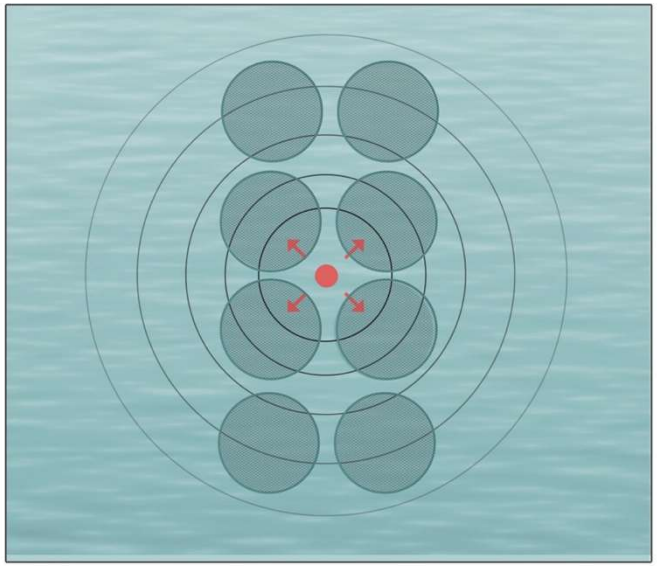
APPENDIX IX: Sea Lice Prevention Methods (cont'd)

Lice Prevention Methods	Description	Acceptable?
Submerged pen	Pen which keeps salmon deep in the water column, remains fully submerged under the surface for an extended period (a) or has tubes/access to the surface (b). Fully submerged pens must provide salmon with access to air on at least a weekly basis.  (a)  (b)	Yes

APPENDIX IX: Sea Lice Prevention Methods (cont'd)

Lice Prevention Methods	Description	Acceptable?
Cleaner fish	Lumpfish or wrasse added to sea pens to eat sea lice off salmon. See Standard 6.1 for further details on cleaner fish use.  Lumpfish *(Cyclopterus lumpus)*  Ballan wrasse *(Labrus bergylta)*	Steps 1 and 3 only.
Parasiticides in feed	Prescribed additives to feed which kill or prevent sea lice infestation.	Yes
Functional feed	Feeds that boost salmon's mucous production in order to inhibit lice attachment and do not contain parasiticides.	Yes
Surface freshwater	A layer of freshwater kept near the surface of the pen/tank which salmon naturally swim through in order to refill their swim bladder or feed at the surface.	Yes

APPENDIX IX: Sea Lice Prevention Methods (cont'd)

Lice Prevention Methods	Description	Acceptable?
Ultrasound	G.A.P. is aware that ultrasound technologies are being tested and developed for the purpose of lice removal/prevention. Until research has become more conclusive and possible impacts on fish welfare explored, it is prohibited.  Overhead view of pens	**No**

APPENDIX X: Quality Grades of Farmed Atlantic Salmon

Slaughter facilities will quality grade all salmon as part of processing. See G.A.P.'s Farmed Atlantic Salmon Animal Welfare Slaughter Facility Standard for more details.

Per Section 13.2, for each processing event of G.A.P. Certified salmon, the slaughter facility will quality grade **100 salmon**, keeping a record of the percentage in each grade and sharing the results with the G.A.P. Certified salmon farm. This quality grading assessment focuses on welfare outcomes rather than meat quality grading.

The table below outlines the criteria for each grade. A salmon must meet all criteria in the grade, or drop to the next applicable grade.

Criteria	Grade A	Grade B	Grade C
Punctures	None	None	≥ 1
Bruises	None	≤ 1 and < 0.5in (1.3 cm) in diameter	> 1 or ≥ 0.5 inch (1.3 cm)
Fins	Whole fins intact	Some spread fin rays without soft tissue	Damaged, non-existent, or bleeding fins
Open Sores	None	None	≥ 1
Scale Loss	≤ 15%	≤ 25%	≥ 26%
Eyes	Clear	Dull	Cloudy/milky
Deformities	None	None	Deformed jaw, crooked backbone, or shortened operculum

Adapted from: (http://yousyokuburi.com/pdf/Quality_grading_of_farmed_salmon.pdf) and (https://www.yumpu.com/en/document/read/36115537/salmon-grades-tables-alaska-seafood-marketing-institute)

Glossary

Term	Definition
Adhesion(s)	*Bands of scar-like tissue that form between two surfaces inside the body that are not normally joined together*
Adult salmon	*Salmon which have fully smoltified and live entirely in seawater, are normally raised to a weight between 3 and 5 kg.*
Alevin	*Newly hatched salmon still carrying its yolk on its stomach.*
Area Management Agreement	*Signed contract between various stakeholders (can include but is not limited to government, NGOs, first nation communities, or other farm facilities) which sets parameters for a farm's use of land, water, and/or natural resources where the farm is located.*
Benthic	*The floor of a body of water (can be freshwater or sea water)*
Broodstock	*Adult salmon raised to sexual maturity for the purpose of breeding, usually selected for specific genetic traits.*
By-Product	*Animal waste and products derived from slaughter/harvest process including blood or any of its components, meat, bone, bristles, flesh, hair, hides, hooves, horns, offal, skins, fat, and/or feathers.*
Cleaner Fish	*A fish that removes parasites from other fishes; fish which are stocked into marine net pens for the sole purpose of eating/removing sea lice from salmon.*
Crowding	*The process by which fish are brought together into a smaller area so that they can be netted and pumped for the purposes of grading, health checks, transport, treatment, and slaughter.*
Cull (or culling)	*A fish that has been removed by a caretaker and killed as a health management decision.*
Dry Brail	*A net used to catch fish which is unlined (e.g.the water drains out when net is lifted out of water).*
Egg	*Also referred to as "ova" or "roe", embryonic life stage of salmon*
Endemic Species	*Species which are native or indigenous to a specific area or range.*
Fall out animal	*An animal within the stock that does not meet the requirements of the Standards and* ***cannot be marketed as GAP Certified.***

Fallowing	*Leaving an open water aquaculture site inactive and unstocked for a period of time; usually between slaughter of one year-class and restocking of smolts from another.*
FIFO Ratio	*The fish in/fish out ratio (FIFO) measures the amount of fish meal and fish oil that is used to produce one weight equivalent of farmed fish back to wild fish weight equivalents.*
First Feed	*Also known as "starter feed," given to fry when they have absorbed their yolk sac and are ready for solid food.*
Freshwater Stage/Phase/Production	*Life stage of salmon that is spent entirely in freshwater (salinity on average < .5 ppm).*
Fry	*Developmental stage of salmon immediately following alevin, usually about one-month post-hatch; they have consumed their yolk sac, are able to swim freely and feed on live prey.*
Genetically modified	*Salmon who have been genetically altered (modified, engineered) or cloned. This does not include salmon that are genetically selected for certain traits.*
Grading	*The process by which fish are sorted by size (e.g. to reduce aggression, prepare for harvest)*
Grandfathered	*In the G.A.P. program, a grandfather clause is applied only at the initial audit, to exempt certain animals from the requirements of a standard due to the operation being unaware of the requirements of the G.A.P. standards*
Hatchery	*A facility which manages broodstock, eggs, and may manage up to first feed fry (max weight 5g).*
Hide	*A structure within the pen which provides an area for fish to shelter or hide.*
Juvenile	*Any salmon of smolt age or younger; includes smolts, fry, parr, alevin, but **excludes** ova.*
Market Animals	*Any animal selected for slaughter/consumption.*
Milt	*The semen of a male fish.*
Mortality	*A record of animals that have died. There are four categories of mortality: (a) fish that are found dead through natural causes, (b) fish found dead through predation, (c) fish that are culled and (d) fish that are missing (i.e. escapes).*
Non-endemic Species	*Species which have been introduced into an area which is not an historical part of their range or habitat.*
Off-label / extra-label medication	*Off-label use is the use of pharmaceutical drugs for an unapproved indication or in an unapproved age group, unapproved dosage, or unapproved form of administration.*

On-Farm Euthanasia	*The act of killing individual fish in response to an irrecoverable illness or injury.*
Open-valve system	*The system or practice by which wellboats are able to allow fresh oxygenated water into holding bays during live transport of fish.*
Operation	*A farm of single or multiple stages of production that meets all of the following criteria:* *a. all staff and fish are under the direct supervision* of the main farm;* *b. the main farm owns all of the fish; and* *c. the main farm owns, rents or leases, all the land (including any underwater land area), sea pens, support vessels (feed barge) and/or buildings (hatcheries) where the fish are kept.* *An individual operation can include a farm that is under contract to raise juvenile fish for a larger business OR a farm that owns their own fish and markets them under their own brand(s).* **Direct supervision is defined as being when an employee of the main certified farm business is responsible for the fish on the farm that is at a separate location to the main farm. If the person responsible for the management and care of the fish at a separate location to the main certified farm business is a contract farmer and not an employee, then that site is a separate operation for the purposes of determining the number of audits – even if there is routine oversight from an employee of the main operation*
Organophosphates	*Chemical compounds often used as pesticides, which have been shown to have adverse effects on the nervous system of humans and animals.*
Parr	*A juvenile stage of Atlantic salmon following the fry stage; when fry reach 8-10 cm in length, they develop dark stripes ("parr marks") which define this life stage until smoltification.*
Parasiticides	*A substance used in veterinary medicine to kill parasites.*
Pre-Smolt	*A juvenile salmon which is undergoing the physiological change necessary to survive in seawater. This change begins to occur up to 1 year of age.*
Priest	*A small baton or club with a weighted end that can be used to humanely euthanize fish.*
Pumping	*Process by which salmon are transported from one area to another via pipe, which lifts fish out of the water and transports them to a receiving area. "Pumping" encompasses all pumping systems (i.e. vacuum pump, venturi pump, etc.) used for this purpose.*
Quality Grading	*A composite evaluation of factors that affect the palatability of salmon flesh, e.g. color, firmness, smell, etc.*
RAS (Recirculating Aquaculture System)	*A land-based tank system which operates by filtering water and recirculating it throughout the system.*

Pen, Open Water Pen	*A pen is any cage or net system which holds fish in open water.*
Refuge	*A structure within the pen which provides an area for fish to shelter or hide.*
Seawater Stage/Phase/Production	*Life stage of salmon that is spent entirely in seawater (salinity ≥ 10 ppm)*
Smolt	*A young salmon (usually about 1+ years old) which has gone through the physiological change necessary to live in full-salinity seawater; has turned silvery and have lost its dark markings.*
Stock	*The total population of fish at any given time on a single operation.*
Sub-therapeutic	*Administering treatment when animals are not sick; this includes low doses of medication over an extended period of time.*
Tank	*A structure created to hold and grow fish in water. A tank is located on land.*
Triploid Salmon	*Salmon which are sterile; having 3 sets of chromosomes instead of 2 (thus rendering the fish sterile).*
Veterinarian-Client-Patient Relationship (VCPR)	*A VCPR is present when all of the following requirements are met:* *1. The veterinarian has assumed the responsibility for making clinical judgments regarding the health of the patient and the client has agreed to follow the veterinarians' instructions.* *2. The veterinarian has sufficient knowledge of the patient to initiate at least a general or preliminary diagnosis of the medical condition of the patient. This means that the veterinarian is personally acquainted with the keeping and care of the patient by virtue of a timely examination of the patient by the veterinarian, or medically appropriate and timely visits by the veterinarian to the operation where the patient is managed.* *3. The veterinarian is readily available for follow-up evaluation or has arranged for the following: veterinary emergency coverage, and continuing care and treatment.* *4. The veterinarian provides oversight of treatment, compliance, and outcome.* *5. Patient records are maintained.* *This VCPR definition has been adopted from the American Veterinary Medical Association (AVMA).*
Wellboat	*A boat designed for the transport of marine organisms in a large well or holding tank within the boat. Can contain the option for a closed or open-valve well system.*
Year Class	*All the fish stocked into a defined management area in a continuous twelve-month period.*

KEY REFERENCES UTILIZED TO CREATE THIS STANDARD

1. Aas, T.S., Ytrestøyl, T., Hatlen, B., Sixten, H.J., Hillestad, M., Åsgård, T., 2013. Gastrointestinal passage rate in Atlantic salmon (*Salmo salar*) feed dry or soaked feed. Nofima Report 38/2013.
2. Aas, T.S., Ytrestøyl, T., Hatlen, B., Sixten, H.J., Hillestad, M., Selset, R., Åsgård, T., 2014. Gut evacuation rate in Atlantic salmon (*Salmo salar*) fed diets with different physical properties. Nofima Report 33/2014.
3. Arechavala-Lopez, P., Diaz-Gil, C. Saraiva, J.L., Moranta, D., Castanheira, M.F., Nunez-Velazquez, S., Ledesma-Corvi, S., Mora-Ruiz, M.R., Grau, A., 2019. Effects of structural environmental enrichment on welfare of juvenile seabream (*Sparus aurata*). *Aquaculture Reports* 15, 100224.
4. Ashley, P.J., 2007. Fish welfare: current issues in aquaculture. *Applied Animal Behaviour Science* 104, 199-235.
5. Assefa, A., and Abunna, F., 2018. Maintenance of fish health in aquaculture: review of epidemiological approaches for prevention and control of infectious disease of fish. *Veterinary Medicine International*, Volume 2018, Article ID: 5432497.
6. Aunsomo, A., Bruheim, T., Sandberg, M., Skjerve, E., Romstad, S., Larssen, R.B., 2008. Methods for investigating patterns of mortality and quantifying cause-specific mortality in sea-farmed Atlantic salmon *Salmo salar. Diseases of Aquatic Organisms* Vol. 81: 99-107.
7. Bakke-McKellep, A.M., Sanden, M., Danieli, A., Acierno, R., Hemre, G-I., Maffia, M., Krogdahl, Å., 2008. Atlantic salmon (*Salmo salar* L.) parr fed genetically modified soybeans and maize: histological, digestive, metabolic, and immunological investigations. *Research in Veterinary Science* 84, 395-408.
8. Baldwin, L., 2010. The effects of stocking density on fish welfare. *The Plymouth Student Scientist*, **4**(1), 372-383.
9. Bannister J., Sievers, M., Bush, F., Bloecher, N., 2019. Biofouling in marine aquaculture: a review of recent research and developments. *Biofouling* 35:6, 631-648.
10. Barber, I., 2007. Parasites, behaviour and welfare in fish. *Applied Animal Behaviour Science* 104, 251-264.
11. Barrett, L.T., Bui, S., Oppedal, F., Bardal, T., Olsen, R.E., Dempster, T., 2020. Ultraviolet-C light suppresses reproduction of sea lice but has adverse effects on host salmon. *Aquaculture* 520 734954.
12. Belghit, I., Liland, N.S., Gjesdal, P., Biancarosa, I., Menchetti, E., Li, Y., Waagbø, R., Kroghdahl, Å., Lock, E-J., 2019. Black soldier fly larvae meal can replace fish meal in diets of sea-water phase Atlantic salmon (*Salmo salar*). *Aquaculture* 503: 609-619.
13. Berg, A., Røsdeth, O.M., Tangerås, A., Hansen, T., 2006. Time of vaccination influences development of adhesions, growth and spinal deformities in Atlantic salmon *Salmo salar*. *Diseases of Aquatic Organisms* Vol. 69: 239-248.
14. Bergh, O., 2007. The dual myths of the healthy wild fish and the unhealthy farmed fish. *Diseases of Aquatic Organisms* Vol. 75: 159-164.
15. Bermejo-Poza, R., De la Fuente, J., Pérez, C., Lauzurica, S., González de Chávarri, E., Diaz, M.T., Villarroel, M., 2016. Reducing the effect of pre-slaughter fasting on the stress response of rainbow trout (*Oncorhynchus mykiss*). *Animal Welfare* 25: 339-346.
16. Bolton-Warberg, M, 2017. An overview of cleaner fish used in Ireland. *Journal of Fish Diseases* 2018;41:935-939.

17. Bosworth, B.G., Small, B.C., Gregory, D., Kim, J., Black, S., Jerrett, A., 2007. Effects of rested-harvest using the anesthetic AQUI-S^{TM} on channel catfish, *Ictalurus punctatus,* physiology and fillet quality. *Aquaculture* 262, 302-318.
18. Bowden, A.J., Andrewartha, S.J., Elliott, N.G., Frappell, P.B., Clark, T.D., 2018. Negligible differences in metabolism and thermal tolerance between diploid and triploid Atlantic salmon (*Salmo salar*). *Journal of Experimental Biology* 221, jeb166975. doi:10.1242/jeb.166975.
19. Boxaspan, K., 2006. A review of the biology and genetics of sea lice. *ICES Journal of Marine Science* 63: 1304-1316.
20. Braithwaite, V.A., 2017. Assessing fish welfare. *CAB Reviews* **12**, No. 023.
21. Braithwaite, V.A., and Salvanes, A.G.V., 2010. Aquaculture and restocking: implications for conservation and welfare. *Animal Welfare* 19: 139-149 ISSN 0962-7286.
22. Braithwaite, V.A., Boulcott, P., 2007. Pain perception, aversion and fear in fish. *Diseases of Aquatic Organisms* Vol. 75: 131-138.
23. Bratland, S., Stien, L.H., Braithwaite, V.A., Juell, J-E., Folkedal, O., Nilsson, J., Oppedal, F., Fosseidengen, J.E., Kristiansen, T., 2010. From fright to anticipation: using aversive light stimuli to investigate reward conditioning in large groups of Atlantic salmon (*Salmo salar*). *Aquaculture International* 18:991-1001.
24. Brooker, Adam J., Davie, A., Leclercq, E., Zerafa, B., Migaud, H., 2020. Pre-deployment acclimatisation of farmed ballan wrasse (*Labrus bergylta*) to sea-cage conditions promotes behavior analogous to wild conspecifics when used as cleaner fish in Atlantic salmon (*Salmo salar*) farms. *Aquaculture* 520, 734771.
25. Brooker, Adam J., Papadopoulou, A., Guitiérrez, C., Rey, S., Davie, A., Migaud, H., 2018. Sustainable production and use of cleaner fish for the biological control of sea lice: recent advances and current challenges. *Veterinary Records*, 183, 383.
26. Brown, C., 2015. Fish intelligence, sentience and ethics. *Animal Cognition* (1), 1-17.
27. Brown, C., and Dorey, C., 2019. Pain and emotion in fishes- fish welfare implications for fisheries and aquaculture. *Animal Studies Journal* Vol. 8 (2), 175-201.
28. Brown, C., Davidson, T., Laland, K., 2003. Environmental enrichment and prior experience of live prey improve foraging behavior in hatchery-reared Atlantic salmon. *Journal of Fish Biology* 63 (Supplement A), 187-196.
29. Bui, S., Oppedal, F., Korsøen, Ø.J., Dempster, T., 2013. Modifying Atlantic salmon behavior with light or feed stimuli may improve parasite control techniques. *Aquaculture Environment Interactions* Vol. 3: 125-133.
30. Bui, S., Oppedal, F., Korsøen, Ø.J., Sonny, Damien, Dempster, T., 2013. Group behavioural responses of Atlantic salmon (*Salmo salar* L.) to light, infrasound and sound stimuli. *PLoS ONE* 8(5): e63696. doi:10.1371/journal.pone.0063696.
31. Bui, S., Oppedal, F., Sievers, M., Dempster, T., 2017. Behaviour in the toolbox to outsmart parasites and improve fish welfare in aquaculture. *Reviews in Aquaculture* **0**, 1-19.
32. Bui, S., Oppedal, F., Stien, L., Dempster, T., 2016. Sea lice infestation level alters salmon swimming depth in sea-cages. *Aquaculture Environment Interactions* Vol. 8: 429-435.
33. Bui, S., Stien, L.H., Nilsson, J., Trengereid, H., Oppedal, F., 2020. Efficiency and welfare impact of long-term simultaneous in situ management strategies for salmon louse reduction in commercial sea cages. *Aquaculture* 520 734934.
34. Byelashov, O.A., and Griffin, M.E., 2014. Fish in, fish out: perception of sustainability and contribution to public health. *Fisheries*, 39:11, 531-535.

35. Calabrese, S., Nilsen, T.O., Kolarevic, J., Ebbesson, L.O.E., Pedrosa, C., Fivelstad, S., Hosfeld, C., Stefansson, S.O., Terjesen, B.F., Takle, H., Martins, C.I.M., Sveier, H., Mathisen, F., Imslad, A.K., Handeland, S.O., 2017. Stocking density limits for post-smolt Atlantic salmon (*Salmo salar* L.) with emphasis on production performance and welfare. *Aquaculture* 468, 363-370.
36. Cao, Y., Tveten, A-K., Stene, A., 2017. Establishment of a non-invasive method for stress evaluation in farmed salmon based on direct fecal corticoid metabolites measurement. *Fish and Shellfish Immunology* 66, 317-324.
37. Carlberg, H., Cheng, K., Lundh, T., Brännäs, E., 2015. Using self-selection to evaluate the acceptance of a new diet formulation by farmed fish. *Applied Animal Behaviour Science* 17, 226-232.
38. Carrs, D.N., 1990. Concentrations of wild and escaped fishes immediately adjacent to fish farm cages. *Aquaculture* 90, 29-40.
39. Castro, C.A.C., Hernández, L.H.H., Araiza, M.A.F., Pérez, T.R., López, O.A., 2011. Effects of diets with soybean meal on the growth, digestibility, phosphorous and nitrogen excretion of juvenile rainbow trout *Oncorhynchus mykiss*. *Hidrobiológica* , 21(2):118-125.
40. Chezik, K.A., Lester, N.P., Venturelli, P.A., 2013. Fish growth and degree-days I: selecting a base temperature for a within-population study. *Canadian Journal of Fish and Aquatic Sciences* **71**: 47-55.
41. Colson, V., Mure, A., Valotaire, C., Le Calvez, J.M., Goardon, L., Labbe, L., Leguen, I., Prunet, P., 2019. A novel emotional and cognitive approach to welfare phenotyping in rainbow trout exposed to poor water quality. *Applied Animal Behaviour Science* 210, 103-112.
42. Colson, V., Sadoul, B., Valotaire, C., Prunet, P., Gaumé, M., Labbé, L., 2015. Welfare assessment of rainbow trout reared in a Recirculating Aquaculture System: comparison with a flow-through system. *Aquaculture* 436, 151-159.
43. Coram, A., Gordon, J., Thompson, D. and Northridge, S (2014). Evaluating and assessing the relative effectiveness of non-lethal measures, including Acoustic Deterrent Devices, on marine mammals. Scottish Government.
44. Coyle, S.D., Durborow, R.M. and Tidwell, J.H., 2004. Anesthetics in aquaculture. Southern Regional Aquaculture Center Publication No. 3900.
45. Culbert, B.M., Gilmour, K.M., Balshine, S., 2019. Social buffering of stress in a group-living fish. *Proceedings of the Royal Society B* 286: 20191626.
46. Davidson, J., and Good, C., 2015. A review of factors influencing maturation of Atlantic salmon *Salmo salar* with focus on water recirculation aquaculture system environments. The Conservation Fund's Freshwater Institute Report, September 2015, 76 pages.
47. Davidson, J., Barrows, F.T., Kenney, P.B., Good, C., Schroyer, K., Summerfelt, S.T., 2016. Effects of feeding a fishmeal-free versus a fishmeal-based diet on post-smolt Atlantic salmon *Salmo salar* performance, water quality, and waste production in recirculation aquaculture systems. *Aquaculture Engineering* 74, 38-51.
48. Davidson, J., May, T., Good, C., Waldrop, T., Kenney, B., Terjesen, B.F., Summerfelt, S., 2016. Production of market-size North American strain Atlantic salmon *Salmo salar* in a land-based recirculation aquaculture system using freshwater. *Aquaculture Engineering* 74, 1-16.
49. Dempster, T., Bui, S., Overton, K., Oppedal, F., 2019. Jumping to treat sea lice: harnessing salmon behaviour to enable surface-based chemotherapeutant application. *Aquaculture* 512, 734318.

50. Dempster, T., Kristiansen, T.S., Korsøen, Ø.J., Fosseidengen, J.E., Oppedal, F., 2014. Technical note: modifying Atlantic salmon (*Salmo salar*) jumping behavior to facilitate innovation of parasitic sea lice control techniques. *Journal of Animal Science*, 89: 4281-4285.
51. Dempster, T., Uglem, I., Sanchez-Jerez, P., Fernandez-Jover, D., Bayle-Sempere, J., Nilsen, R., Bjørn, P.A., 2009. Coastal salmon farms attract large and persistent aggregations of wild fish: an ecosystem effect. *Marine Ecology Progress Series* Vol. 385: 1-14.
52. Ebbesson, L.O.E., and Braithwaite, V.A., 2012. Environmental effects on fish neural plasticity and cognition. *Journal of Fish Biology* 81, 2151-2174.
53. Ellis, T., Turnbull, J.F., Knowles, T.G., Lines, J.A., Auchterlonie, N.A., 2016. Trends during the development of Scottish salmon farming: an example of sustainable intensification? *Aquaculture* 458, 82-99.
54. Eriksen, M.S., Faerevik, G., Kittilsen, S., McCormick, M.I., Damsgard, B., Braithwaite, V.A., Braastad, B.O., and Bakken, M., 2011. Stressed mothers - troubled offspring: a study of behavioural maternal effects in farmed *Salmo salar*. *Journal of Fish Biology* 79, 575-586.
55. Erikson, U., Gansel, L., Frank, K., Svendsen, E., Digre, H., 2016. Crowding of Atlantic salmon in net-pen before slaughter. *Aquaculture* 465, 395-400.
56. Espmark, Å.M., Midling, K.Ø., Nilsson, J., Humborstad, O-B., 2016. Effects of pumping height and repeated pumping in Atlantic salmon *Salmo salar. Natural Resources* 7, 377-383.
57. Evans, M.L., Hori, T.S., Rise, M.L., Fleming, I.A., 2015. Transcriptomic responses of Atlantic salmon (*Salmo salar*) to environmental enrichment during juvenile rearing. *PLoS ONE* 10(3): e0118378. doi:10.1371/journal.pone.0118378.
58. Fife-Cook, I., and Franks, B., 2019. Positive welfare for fishes: rationale and areas of future study. *Fishes* 4, 31; doi:10.3390/fishes4020031.
59. Figueroa, C., Bustos, P., Torrealba, D., Dixon, B., Soto, C., Conejeros, P., Gallardo, J.A., 2017. Coinfection takes its toll: sea lice override the protective effects of vaccination against a bacterial pathogen in Atlantic salmon. *Scientific Reports* 7:17817.
60. Fjelldal, P.G., Schulz, R., Nilsen, T.O., Andersson, E., Norberg, B., and Hansen, T.J., 2018. Sexual maturation and smoltification in domesticated Atlantic salmon (*Salmo salar,* L.) - is there a developmental conflict? *Physiological Reports*, 6(17), 2018, e13809.
61. Fjelldal, P.G., Solberg, M.F., Glover, K.A., Folkedal, O., Nilsson, J., Finn, R.N., Hansen, T.J., 2018. Documentation of multiple species of marine fish trapped in Atlantic salmon sea-cages in Norway. *Aquatic Living Resources* 31, 31.
62. Fjelldal, P.G., Wennevik, V., Fleming, I.A., Hansen, T., Glover, K.A., 2014. Triploid (sterile) farmed Atlantic salmon males attempt to spawn with wild females. *Aquaculture Environment Interactions* Vol. 5: 155-162.
63. Folkedal, O., Pettersen, J.M., Bracke, M.B.M., Stien, L.H., Nilsson, J., Martins, C., Breck, O., Midtlyng, P.J., Kristiansen, T., 2016. On-farm evaluation of the Salmon Welfare Index Model (SWIM 1.0): theoretical and practical considerations. *Animal Welfare* 25: 135-149.
64. Folkedal, O., Stien, L.H., Nilsson, J., Torgersen, T., Fosseidengen, J.E., Oppedal, F., 2012. Sea caged Atlantic salmon display size-dependent swimming depth. *Aquatic Living Resources* 25, 143-149.

65. Folkedal, O., Stien, L.H., Torgersen, T., Oppedal, F., Olsen, R.E., Fosseidengen, J.E., Braithwaite, V.A., Kristiansen, T.S., 2012. Food anticipatory behaviour as an indicator of stress response and recovery in Atlantic salmon post-smolt after exposure to acute temperature fluctuation. *Physiology and Behavior* 105, 350-356.
66. Føre, M., Frank, K., Norton, T., Svendsen, E., Alfredsen, J.A., Dempster, T., Eguiraun, H., Watson, W., Stahl, A., Sunde, L.M., Schellewald, C., Skøien, K.R., Alver, M.O., Berckmans, D., 2018. Precision fish farming: a new framework to improve production in aquaculture. *Biosystems Engineering* 173, 176-193.
67. Føre, M., Svendson, E., Alfredsen, J.A., Uglem, I., Bloecher, N., Sveier, H., Sunde, L.M., Frank, K., 2018. Using acoustic telemetry to monitor the effects of crowding and delousing procedures on farmed Atlantic salmon (*Salmo salar*). *Aquaculture* 495, 757-765.
68. Forseth, T., Barlaup, B.T., Finstad, B., Fiske, P., Gjøsæter, H., Falkegård, M., Hindar, A., Mo, T.A., Rikardsen, A.H., Thorstad, E.B., Vøllestad, L.A., Wennevik, V., 2017. The major threats to Atlantic salmon in Norway. *ICES Journal of Marine Science*, doi:10.1093/icesjms/fsx020.
69. Forseth, T., Barlaup, B.T., Finstad, B., Fiske, P., Gjøsæter, H., Falkegård, M., Hindar, A., Mo, T.A., Rikardsen, A.H., Thorstad, E.B., Vøllestad, L.A., Wennevik, V., 2017. The major threats to Atlantic salmon in Norway. *ICES Journal of Marine Science*, 74(6), 1496-1513.
70. Fraser, T.W.K., Fjelldal, P.G., Hansen, T., Mayer, I., 2012. Welfare considerations of triploid fish. *Reviews in Fisheries Science* 20(4), 192-211.
71. Frenzl, B., Stien, L.H., Cockerill, D., Oppedal, F., Richards, R.H., Shinn, A.P., Bron, J.E., Migaud, H., 2014. Manipulation of farmed Atlantic salmon swimming behaviour through the adjustment of lighting and feeding regimes as a tool for salmon lice control. *Aquaculture* 424-425, 183-188.
72. Fry, J.P., Mailloux, N.A., Love, D.C., Milli, M.C., Cao, L., 2018. Feed conversion efficiency in aquaculture: do we measure it correctly? *Environmental Research Letters* 13, 024017.
73. Gaffney, L.P., Franks, B., Weary, D.M., von Keyserlingk, M.A.G., 2016. Coho salmon (*Oncorhynchus kisutch*) prefer and are less aggressive in darker environments. *PLoS ONE* 11(3): e0151325. doi:10.1371/journal.pone.0151325.
74. Gallardo-Escárate, C., Arriagada, G., Carrera, C., Gonçalves, A.T., Nuñez-Acuña, G., Valenzuela-Miranda, D., Valenzuela-Muñoz, V., 2019. The race between host and sea lice in the Chilean salmon farming: a genomic approach. *Reviews in Aquaculture* **11**, 325-339.
75. Garseth, Å.H., Fristvold, C., Svendson, J.C., Jensen, B.B., Mikalsen, A.B., 2017. Cardiomyopathy syndrome in Atlantic salmon *Salmo salar* L.: a review of the current state of knowledge. *Journal of Fish Diseases* 41: 11-26.
76. Gatica, M.C., Monti, G.E., Knowles, T.G., Warriss, P.D., Gallo, C.B., 2010. Effects of commercial live animal transportation and preslaughter handling of Atlantic salmon on blood constituents. *Archivos de Medicina Veterinaria* 42, 73-78.
77. Gentry, K., Bui, S., Oppedal, F., Dempster, T., 2020. Sea lice prevention strategies affect cleaner fish delousing efficacy in commercial Atlantic salmon sea cages. *Aquaculture Environment Interactions* Vol 12: 67-80, 2020.
78. Gerber, B., Stamer, A., Stadtlander, T. Environmental enrichment and its effects on welfare in fish. *FiBL*.
79. Glaropoulos, A., Stien, L.H., Folkedal, O., Dempster, T., Oppedal, F., 2019. Welfare, behavior and feasibility of farming Atlantic salmon in submerged cages with weekly surface access to refill their swim bladders. *Aquaculture* 502, 332-337.

80. Glover, K.A., Hansen, T., Besnier, F., Solberg, M.F., Fjelldal, P.G., Eide, A.G.S., Dalvin, S., Nilsen, F., 2017. Cloned and outbred Atlantic salmon display equal parasitic dispersion when infected with the salmon louse. *Aquaculture* 480, 83-88.
81. Glover, K.A., Madhun, A.S., Dahle, G., Sørvik, A.G.E., Wennevik, V., Skaala, Ø., Mortain, H.C., Hansen, T.J., Fjelldal, P.G., 2015. The frequency of spontaneous triploidy in farmed Atlantic salmon produced in Norway during the period 2007-2014. *BMC Genetics* 16:37.
82. Godfrey, J.D., Stewart, D.C., Middlemas, S.J., Armstrong, J.D., 2015. Depth use and migratory behavior of homing Atlantic salmon (*Salmo salar*) in Scottish coastal waters. *ICES Journal of Marine Science* 72(2), 568-575.
83. Götz, T., Janik, V.M., 2013. Acoustic deterrent devices to prevent pinniped depredation: efficiency, conservation concerns and possible solutions. *Marine Ecology Progress Series* Vol 492: 285-302.
84. Grøntvedt, R.N., Kristoffersen, A.B., Jansen, P.A., 2018. Reduced exposure of farmed salmon to salmon louse (*Lepeophtheirus salmonis* L.) infestation by use of plankton nets: estimating the shielding effect. *Aquaculture* 495, 865-872.
85. Handeland, S.O., Imsland, A.K., Ebbesson, L.O.E., Nilsen, T.O., Hosfeld, C.D., Baeverfjord, G., Espmark, Å., Rosten, T., Skilbrei, O.T., Hansen, T., Gunnarsson, G.S., Breck, O., Stefansson, S.O., 2013. Low light intensity can reduce Atlantic salmon smolt quality. *Aquaculture* 384-387, 19-24.
86. Harvey, A.C., Solberg, M.F., Troianou, E., Carvalho, G.R., Taylor, M.I., Creer, S., Dyrhovden, L., Matre, I.H., Glover, K.A., 2016. Plasticity in growth of farmed and wild Atlantic salmon: is the increased growth rate of farmed salmon caused by evolutionary adaptations to the commercial diet? *BMC Evolutionary Biology* 16:264.
87. Haskell, S.R.R., Payne, M.A., Webb, A.I., Riviere, J.E., Craigmill, A.L., 2004. Current approved drugs for aquatic species. *JAVMA*, Vol 224, No. 1, January 1, 2004.
88. Hatlen, B., Jakobsen, J-V., Crampton, V., Alm, M., Langmyhr, E., Espe, M., Hevrøy, E.M., Torstensen, B.E., Liland, N., Waagbø, R., 2014. Growth, feed utilization and endocrine responses in Atlantic salmon (*Salmo salar*) fed diets added poultry by-product meal and blood meal in combination with poultry oil. *Aquaculture Nutrition* doi: 10.1111/anu.12194.
89. Hay, D.E., Bravender, B.A., Gillis, D.J., Black, E.A., 2004. An investigation into the consumption of wild food organisms, and possible effects of lights on predation, by caged Atlantic salmon in British Columbia. *Canadian Manuscript Report of Fisheries and Aquatic Sciences 2662.*
90. Helgesen, K.O., Romstad, H., Aaen, S.M., Horsberg, T.E., 2015. First report of reduced sensitivity towards hydrogen peroxide found in the salmon louse *Lepeophtheirus salmonis* in Norway. *Aquaculture Reports* 1, 37-42.
91. Herbert, N., Kadri, S., Huntingford, F., 2011. A moving light stimulus elicits a sustained swimming response in farmed Atlantic salmon, *Salmo salar* L. *Fish Physiological Biochemistry* 37:317-325.
92. Hernández, A.J., Roman, D., 2016. Phosphorous and nitrogen utilization efficiency in rainbow trout (*Oncorhynchus mykiss*) fed diets with lupin (*Lupinus albus*) or soybean (*Glycine max*) meals as partial replacements to fish meal. *Czech Journal of Animal Science* 61(2): 67-74.
93. Huntingford, F.A., and Kadri, S., 2014. Defining, assessing and promoting the welfare of farmed fish. *Scientific and Technical Review of the Office International des Epizooties* 33(1), 233-244.
94. Hvas, M., & Oppedal, F., 2019. Physiological responses of farmed Atlantic salmon and two cohabitant species of cleaner fish to progressive hypoxia. *Aquaculture*, https://doi.org/10.1016/j.aquaculture.2019.734353

95. Hvas, M., Folkedal, O., Imsland, A., Oppedal, F., 2017. The effect of thermal acclimation on aerobic scope and critical swimming speed in Atlantic salmon, *Salmo salar*. *Journal of Experimental Biology* 220, 2757-2764.
96. Hvas, M., Folkedal, O., Imsland, A., Oppedal, F., 2018. Metabolic rates, swimming capabilities, thermal niche and stress response of the lumpfish, *Cyclopterus lumpusˆ*. *Biology Open* 7 bio036079. doi:10.1242/bio.036079
97. Hvas, M., Folkedal, O., Solstorm, D., Vagseth, T., Fosse, J.O., Gansel, L.C., Oppedal, F., 2017. Assessing swimming capacity and schooling behavior in farmed Atlantic salmon *Salmo salar* with experimental push-cages. *Aquaculture* 473, 423-429.
98. Hyvärinen, P., and Rodewald, P., 2014. Enriched rearing improves survival of hatchery-reared Atlantic salmon smolts during migration in the River Tornionjoki. *Canadian Journal of Fisheries and Aquatic Sciences* 70: 1386-1395.
99. Imsland, A.K.D., Reynolds, P., Eliassen, G., Hangstad, T.A., Nytro, A.V., Foss, A., Vikingstad, E., Elvegard, T.A., 2015. Assessment of suitable substrates for lumpfish in sea pens. *Aquaculture International* 23:639–645. DOI 10.1007/s10499-014-9840-0.
100. Imsland, A.K.D., Reynolds, P., Hangstad, T.A., Jonsdoittir, O.D.B., Noble, T., Wilson, M., Mackie, J.A., Elvegard, T.A., Urskog, T.C., Mikalsen, B., 2018. Feeding behavior and growth of lumpfish (*Cyclopterus lumpus* L.) fed with feed blocks. *Aquaculture Research* 49:2006-2012.
101. Imsland, A.K.D., Reynolds, P., Jonassen, T.M., Hangstad, T.A., Adron, J., Elvegard, T.A., Urskog, T.C., Hanssen, A., Mikalsen, B., 2018. Comparison of diet composition, feeding, growth and health of lumpfish (*Cyclopterus lumpus* L.) fed either feed blocks or pelleted commercial feed. *Aquaculture Research* 1-12.
102. Imsland, A.K.D., Reynolds, P., Lorentzen, M., Eilertsen, R.A., Micallef, J., Tvenning, R., 2020. Improving survival and health of lumpfish (*Cyclopterus lumpus* L.) by the use of feed blocks and operational welfare indicators (OWIs) in commercial Atlantic salmon cages. *Aquaculture* 527, 735476.
103. Jackson, A., 2009. Fish in-fish out ratios explained. *Aquaculture Europe* Vol. 34(3) September 2009.
104. Jacobsen, L., 2005. Otter (*Lutra lutra*) predation on stocked brown trout (*Salmo trutta*) in two Danish lowland rivers. *Ecology of Freshwater Fish* 14: 59-68.
105. Javahery, S., Nekoubin, H., Moradlu, A.H., 2012. Effect of anaesthesia with clove oil in fish (review). *Fish Physiology and Biochemistry*, 38:1545-1552.
106. Jeong, J., and Revie, C.W., 2020. Appropriate sampling strategies to estimate sea lice prevalence on salmon farms with low infestation levels. *Aquaculture* 518 734858.
107. Johannesen, A., Joensen, N.E., Magnussen, E., 2018. Shelters can negatively affect growth and welfare in lumpfish if feed is delivered continuously. *PeerJ*, 6:e4837; DOI 10.7717/peerj.4837.
108. Johansson, D., Laursen, F., Ferno, A., Fosseidengen, J.E., Klebert, P., Stien, L.H., Vagseth, T., Oppedal, F., 2014. The interaction between water currents and salmon swimming behavior in sea cages. *PLoS ONE* 9(5): e97635. doi:10.1371/journal.pone.0097635.
109. Johnsson, J.I., and Naslund, J., 2018. Studying behavioral variation in salmonids from an ecological perspective: observations questions methodological considerations. *Reviews in Fish Biology and Fisheries* 28:795-823.

110. Jones, H.A.C., Noble, C., Damsgård, B., Pearce, G.P., 2012. Investigating the influence of predictable and unpredictable feed delivery schedules upon the behavior and welfare of Atlantic salmon parr (*Salmo salar*) using social network analysis and fin damage. *Applied Animal Behaviour Science* 138, 132-140.
111. Jones, R.E., Petrell, R.J., Pauly, D., 1999. Using modified length-weight relationships to assess the condition of fish. *Aquaculture Engineering* 20: 261-176.
112. Jonsson, B., and Jonsson, N., 2006. Cultured Atlantic salmon in nature: a review of their ecology and interaction with wild fish. *ICES Journal of Marine Science* 63: 1162-1181.
113. Jørgensen, K.M., Wennevik, V., Sørvik, A.G.E., Unneland, L., Prusov, S., Ayllon, F., Glover, K.A., 2018. Investigating the frequency of triploid Atlantic salmon in wild Norwegian and Russian populations. *BMC Genetics* 19:90.
114. Kamunde, C., Sappal, R., Melegy, T.M., 2019. Brown seaweed (AquaArom) supplementation increases food intake and improves growth, antioxidant status and resistance to temperature stress in Atlantic salmon, *Salmo salar. PLoS ONE* 14(7): e0219792. https://doi.org/10.1371/journal.pone.0219792.
115. Karlsson, S., Diserud, O.H., Fiske, P., Hindar, K., 2016. Widespread genetic introgression of escaped farmed Atlantic salmon in wild salmon populations. *ICES Journal of Marine Science* 73(10), 2488-2498.
116. Kihslinger, R., and Nevitt, G.A., 2005. Early rearing environment impacts cerebellar growth in juvenile salmon. *The Journal of Experimental Biology*, 209, 504-509.
117. Kjartansson, H., Fivelstad, S., Thomassen, J.M., Smith, M.J., 1988. Effects of different stocking densities on physiological parameters and growth of adult Atlantic salmon (*Salmo salar* L.) reared in circular tanks. *Aquaculture* 73, 261-274.
118. Kok, B., Malcorps, W., Tlusty, M.F., Eltholth, M.M., Auchterlonie, N.A., Little, D.C., Harmsen, R., Newton, R.W., Davies, S.J., 2020. Fish as feed: using economic allocation to quantify the fish in-fish-out ratio of major fed aquaculture species. *Aquaculture* https://doi.org/10.1016/j.aquaculture.2020.735474.
119. Kousoulaki, K., Olsen, H.J., Albrektsen, S., Langyhr, E., Mjøs, S.A., Campbell, P., Aksnes, A., 2012. High growth rates in Atlantic salmon (*Salmo salar* L.) fed 7.5% fish meal in the diet. Micro-, ultra- and nono-filtration of stickwater and effects of different fractions and compounds on pellet quality and fish performance. *Aquaculture* 338-341, 134-146.
120. Kowalski, R.K., Sarosiek, B., Judycka, S., Dryl, K., Grudniewska, J., Dobosz, S., Cejko, B.I. (2018). Effectiveness of the air stripping in two salmonid fish, rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta* morphia *fario*). *Journal of Visualized Experiments*, e56894, doi:10.379/56894.
121. Kragesteen, T.J., Simonsen, K., Visser, A.W., Andersen, K.H., 2019. Optimal salmon lice treatment threshold and tragedy of the commons in salmon farm networks. *Aquaculture* 734329 https://doi.org/10.1016/j.aquaculture.2019.734329.
122. Kverme, K.O., Haugland, G.T., Hannisdal, R., Kallekleiv, M., Colquhoun, D.J., Lunestad, B.T., Wergeland, H.I., Samuelsen, O.B., 2019. Pharmacokinetics of florfenicol in lumpfish (*Cyclopterus lumpus* L.) after a single oral administration. *Aquaculture* 512, 734279.
123. Lawrence, A.B., Vigors, B., Sandøe, P., 2019. What is so positive about positive animal welfare? – A critical review of the literature. *Animals*, 2019, 9, 783; doi:10.3390/ani9100783.

124. Leclercq, E., Graham, P., Migaud, H., 2015. Development of a water-stable agar-based diet for the supplementary feeding of cleaner fish ballan wrasse (*Labrus bergylta*) deployed within commercial Atlantic salmon (*Salmo salar*) net-pens. *Animal Feed Science and Technology* http://dx.doi.org/10.1016/j.anifeedsci.2015.06.026
125. Leclercq, E., Zarafa, B., Brooker, A.J., Davie, A., Migaud, H., 2018. Application of passive-acoustic telemetry to explore the behaviour of ballan wrasse (*Labrus bergylta*) and lumpfish (*Cyclopterus lumpus*) in commercial Scottish salmon sea-pens. *Aquaculture* 495, 1-12.
126. Levasseur, M., Bergeron, N.E., Lapointe, M.F., Bérubé, F., 2005. Effects of silt and very fine sand dynamics in Atlantic salmon (*Salmo salar*) redds on embryo hatching success. *NRC Research Press* website: http://cjfas.nrc.ca.
127. Li, D., Hao, Y., Duan, Y., 2019. Nonintrusive methods for biomass estimation with emphasis on fish: a review. *Reviews in Aquaculture,* 1-22.
128. Lillehammer, M., Boison, S.A., Norris, A., Løvoll, M., Bakke, H., Gjerde, B., 2019. Genetic parameters of resistance to amoebic gill disease in two Norwegian Atlantic salmon populations. *Aquaculture* 508, 83-89.
129. Lines, J.A., and Spence, J., 2014. Humane harvesting and slaughter of farmed fish. *Scientific and Technical Review of the Office International des Epizooties*, **33**(1), 255-264.
130. Lund, V., Mejdell, C.M., Röcklinsberg, H., Anthony, R., Hästein, T., 2007. Expanding the moral circle: farmed fish as objects of moral concern. *Diseases of Aquatic Organisms* Vol. 75: 109-118.
131. Macaulay, G., Wright, D., Oppedal, F., Dempster, T., 2020. Buoyancy matters: establishing the maximum neutral buoyancy depth of Atlantic salmon. *Aquaculture* 519, 734925.
132. Martin, P., Rancon, J., Segura, G., Laffont, J., Boeuf, G., Dufour, S., 2012. Experimental study of the influence of photoperiod and temperature on the swimming behaviour of hatchery-reared Atlantic salmon (*Salmo salar* L.) smolts. *Aquaculture* 629994, 9 pages.
133. Martins, C.I.M., Galhardo, L., Noble, C., Damsgård, B., Spedicato, M.T., Zupa, W., Beauchaud, M., Kulczykowska, E., Massabuau, J-C., Carter, T., Planellas, S.R., Kristiansen, T., 2012. Behavioural indicators of welfare in farmed fish. *Fish Physiological Biochemistry*, 38:17-41.
134. McConnell, A., Routledge, R., Connors, B.M., 2010. Effect of artificial light on marine invertebrate and fish abundance in an area of salmon farming. *Marine Ecology Progress Series* Vol. 419: 147-156.
135. McGhee, C., Falconer, L., Telfer, T., 2019. What does 'beyond compliance' look like for the Scottish salmon aquaculture industry? *Marine Policy* 109, 103668.
136. Mes, D., van Os, R., Gorissen, M., Ebbesson, L.O.E., Finstad, B., Mayer, I., Vindas, M., 2019. Effects of environmental enrichment on forebrain neural plasticity and survival success of stocked Atlantic salmon. *Journal of Experimental Biology* 222, jeb212258. doi:10.1242/jeb.212258.
137. Millidine, K.J., Armstrong, J.D., Metcalfe, N.B., 2006. Presence of shelter reduces maintenance metabolism of juvenile salmon. *Functional Ecology* 20, 839-845.
138. Miranda, C.D., Godoy, F.A., Lee, M.R., 2018. Current status of the use of antibiotics and the antimicrobial resistance in the Chilean salmon farms. *Frontiers in Microbiology* 9:1284.

139. Morro, B., Balseiro, P., Albalat, A., Pedrosa, C., Mackenzie, S., Nakamura, S., Shimizu, M., Nilsen, T.O., Sveier, H., Ebbesson, L.O., Handeland, S.O., 2019. Effects of different photoperiod regimes on the smoltification and seawater adaptation of seawater-farmed rainbow trout (*Oncorhynchus mykiss*): insights from Na^+, K^+-ATPase activity and transcription of osmoregulation and growth regulation genes. *Aquaculture* 507, 282-292.
140. Mortensen, A., Hansen, O.J., Puvanendran, V., 2016. Evaluation of the three external marking methods of farmed Atlantic salmon for the future use of differentiating it from wild salmon. *Journal of Aquaculture Research and Development* 7:10 DOI: 10.4172/2155-9546.1000451.
141. Mota, V.C., Nilsen, T.O., Gerwins, J., Gallo, M., Ytteborg, E., Baeverfjord, G., Kolarevic, J., Summerfelt, S.T., Terjesen, B.F., 2019. The effects of carbon dioxide on growth performance, welfare and health of Atlantic salmon post-smolt (*Salmo salar*) in recirculating aquaculture systems. *Aquaculture* 498, 578-586.
142. Muggli, A.M., Barnes, J.M., Barnes, M.E., 2019. Vertically-suspended environmental enrichment alters the velocity profiles of circular fish rearing tanks. *World Journal of Engineering and Technology* 7, 208-226.
143. Murray, D.S., Kainz, M.J., Hebberecht, L., Sales, K.R., Hindar, K., Gage, M.J.G., 2018. Comparisons of reproductive function and fatty acid fillet quality between triploid and diploid farm Atlantic salmon (*Salmo salar*). *Royal Society Open Science* **5**: 180493.
144. Naslund, J., Aarestrup, K., Thomassen, S.T., Johnsson, J.I., 2012. Early enrichment effects on brain development in hatchery-reared Atlantic salmon (*Salmo salar*): no evidence for a critical period. *Canadian Journal of Fisheries and Aquaculture Science* 69: 1481-1490.
145. Naslund, J., and Johnsson, J.I., 2014. Environmental enrichment for fish in captive environments: effects of physical structures and substrates. *Fish and Fisheries*, DOI: 10.1111/faf.12088.
146. Naslund, J., Rosengren, M., Del Villar, D., Gansel, L., Norrgard, J.R., Persson, L., Winkowski, J.J., Kvingedal, E., 2013. Hatchery tank enrichment affects cortisol levels and shelter-seeking in Atlantic salmon (*Salmo salar*). *Canadian Journal of Fisheries and Aquaculture Science* 70: 585-590.
147. Nilsen, A., Hagen, Ø., Johnsen, C.A., Prytz, H., Zhou, B., Nielsen, K.V., Bjørnevik, M., 2019. The importance of exercise: increased water velocity improves growth of Atlantic salmon in closed cages. *Aquaculture* 501, 537-546.
148. Nilsen, A., Nielsen, K.V., Biering, E., Bergheim, A., 2017. Effective protection against sea lice during the production of Atlantic salmon in floating enclosures. *Aquaculture* 466, 41-50.
149. Nilsson, J., Moltumyr, L., Madaro, A., Kristiansen, T.S., Gåsnes, S.K., Mejdell, C.M., Gismervik, K., Stien, L.H., 2019. Sudden exposure to warm water causes instant behavioural responses indicative of nociception or pain in Atlantic salmon. *Veterinary and Animal Science* 8 100076.
150. Noble, C., Gismervik, K., Iversen, M.H., Kolarevic, J., Nilsson, J., Stien, L.H., Turnbull, J.F., 2018. Welfare Indicators for farmed Atlantic salmon: tools for assessing fish welfare. 351 pp.
151. Noble, C., Jones, H.A.C., Damsgård, B., Flood, M.J., Midling, K.Ø., Roque, A., Sæther, B-S., Cottee, S.Y., 2012. Injuries and deformities in fish: their potential impact upon aquaculture production and welfare. *Fish Physiological Biochemistry* 38:61-83.

152. Noble, C., Kadri, S., Mitchell, D.F., Huntingford, F.A., 2007. Influence of feeding regime on intraspecific competition, fin damage and growth in 1+ Atlantic salmon parr (*Salmo salar* L.) held in freshwater production cages. *Aquaculture Research* 38, 1137-1143.
153. Nomura, M., Sloman, K.A., von Keyserlingk, M.A.G., Farrell, A.P., 2009. Physiology and behaviour of Atlantic salmon (*Salmo salar*) smolts during commercial land and sea transport. *Physiology and Behavior* 96, 233-243.
154. Nordgreen, J., Bjorge, M.H., Janczak, A.M., Hovland, A.L., Moe, R.O., Ranheim, B., Horsberg, T.E., 2013. The time budget of Atlantic salmon (*Salmo salar*) held in enriched tanks. *Applied Animal Behavior Science* 144 (2013) 147-152.
155. Northridge, S., Coram, A. & Gordon, J. (2013). Investigations on seal depredation at Scottish fish farms. Edinburgh: Scottish Government.
156. O'Flynn, F.M., McGeachy, S.A., Friars, G.W., Benfey, T.J., Bailey, J.K., 1997. Comparisons of cultured triploid and diploid Atlantic salmon (*Salmo salar* L.). *ICES Journal of Marine Science* 54: 1160-1165.
157. Oppedal, F., Dempster, T., Stien, L.H., 2011. Environmental drivers of Atlantic salmon behaviour in sea-cages: A review. *Aquaculture* 311, 1-18.
158. Overton, K., Dempster, T., Oppedal, F., Kristiansen, T.S., Gismervik, K., Stien, L.H., 2018. Salmon lice treatments and salmon mortality in Norwegian aquaculture: a review. *Reviews in Aquaculture*, 1-20.
159. Overton, K., Oppedal, F., Stien, L.H., Moltumyr, L., Wright, D.W., Dempster, T., 2019. Thermal delousing with cold water: effects on salmon lice removal and salmon welfare. *Aquaculture* 505 41-46.
160. Pawlowski, J., Esling, P., Lejzerowicz, F., Cordier, T., Visco, J.A., Martins, C.I.M., Kvalvik, A., Staven, K., Cedhagen, T., 2016. Benthic monitoring of salmon farms in Norway using foraminiferal metabarcoding. *Aquaculture Environment Interactions* Vol. 8 371-386.
161. Peruzzi, S., Puvanendran, V., Riesen, G., Seim, R.R., Hagen, Ø., Martínez-Llorens, S., Falk-Petersen, I-B., Fernandez, J.M.O., Jobling, M., 2017. Growth and development of skeletal anomalies in diploid and triploid Atlantic salmon (*Salmo salar*) fed phosphorous-rich diets with fish meal and hydrolyzed fish protein. *PLoS ONE* 13(3):e0194340. https://doi.org/10.1371/journal.pone.0194340.
162. Poli, B.M., Parisi, G., Scappini, F., Zampacavallo, G., 2005. Fish welfare and quality as affected by pre-slaughter and slaughter management. *Aquaculture International* 13: 29-49.
163. Poppe, T.T., Håstein, T., Frøslie, A., Koppang, N., Norheim, G., 1986. Nutritional aspects of haemorrhagic syndrome ('Hitra disease') in farmed Atlantic salmon *Salmo salar*. *Diseases of Aquatic Organisms* Vol. 1, 155-162.
164. Pounder, K.C., Mitchell, J.C., Thomson, J.S., Pottinger, T.G., Buckley, J., Sneddon, L.U., 2016. Does environmental enrichment promote recovery from stress in rainbow trout? *Applied Animal Behavior Science* 176, 136-142.
165. 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.
166. Priborsky, J., and Velisek, J., 2018. A review of three commonly used fish anesthetics. *Reviews in Fisheries Science and Aquaculture*, 26:4, 417-442.
167. Proboszcz, S. 2019. Wild fish trapped: incidental catch in the salmon farming industry. Watershed Watch Salmon Society. 16 pages.

168. Purcell, J.E., and Arai, M.N., 2001. Interactions of pelagic cnidarians and ctenophores with fish: a review. *Hydrobiologia* **451**: 27-44.
169. Reimer, T., Dempster, T., Wargelius, A., Fjelldal, P.G., Hansen, T., Glover, K.A., Solberg, M.F., Swearer, S.E., 2017. Rapid growth causes abnormal vaterite formation in farmed fish otoliths. *Journal of Experimental Biology*, 220, 2965-2969.
170. Remen, M., Solstorm, F., Bui, S., Klebert, P., Vagseth, T., Solstorm, D., Hvas, M., Oppedal, F., 2016. Critical swimming speed in groups of Atlantic salmon *Salmo salar. Aquaculture Environment Interactions* Vol. 8: 659-664.
171. Robb, D.H.F., 2008. Welfare of fish at harvest. Fish Welfare, edited by Edward J. Branson, John Wiley & Sons, Incorporated, 2008. ProQuest Ebook Central,http://ebookcentral.proquest.com/lib/uoguelph/detail.action?docID=470438. Created from uoguelph on 2019-12-02 11:29:53.
172. Roberts, L.J., Taylor, J., Garcia de Leaniz, C., 2011. Environmental enrichment reduces maladaptive risk-taking behavior in salmon reared for conservation. *Biological Conservation* 144, 1972-1979.
173. Rosengren, M., Kvingedal, E., Naslund, J., Johnsson, J.I., Sundell, K., 2016. Born to be wild: effects of rearing density and environmental enrichment on stress, welfare, and smolt migration in hatchery-reared Atlantic salmon. *Canadian Journal of Fisheries and Aquaculture Science* 74: 396-405.
174. Sievers, M., Korsøen, Ø., Dempster, T., Fjelldal, P.G., Kristiansen, T., Folkedal, O., Oppedal, F., 2018. Growth and welfare of submerged Atlantic salmon under continuous lighting. *Aquaculture Environment Interactions* Vol. 10: 501-510.
175. Skar, M.W., Haugland, G.T., Powell, M.D., Wergeland, H.I., Samuelsen, O.B., 2017. Development of anaesthetic protocols for lumpfish (*Cyclopterus lumpus* L.): Effect of anaesthetic concentrations, sea water temperature and body weight. *PLoS ONE*, 12(7): e0179344. https://doi.org/10.1371/journal.pone.0179344.
176. Sneddon, L.U., 2012. Clinical anesthesia and analgesia in fish. *Journal of Exotic Pet Medicine,* 21(1), 32-43.
177. Sogari, G., Amato, M., Biasato, I., Chiesa, S., Gasco, L., 2019. The potential role of insects as feed: a multi-perspective view. *Animals* 9, 119; doi:10.3390/ani9040119.
178. Solas, M.R., Skoglund, H., Salvanes, A.G.V., 2019. Can structural enrichment reduce predation mortality and increase recaptures of hatchery-reared Atlantic salmon *Salmo salar* L. fry released in the wild? *Journal of Fish Biology*, 95:575-588.
179. Solberg, M.F., Zhang, Z., Glover, K.A., 2015. Are farmed salmon more prone to risk than wild salmon? Susceptibility of juvenile farm, hybrid and wild Atlantic salmon *Salmo salar* L. to an artificial predator. *Applied Animal Behaviour Science* 162, 67-80.
180. Solstorm, F., Solstorm, D., Oppedal, F., Olsen, R.E., Stien, L.H., Ferno, A., 2016. Not too slow, not too fast: water currents affect group structure, aggression and welfare in post-smolt Atlantic salmon *Salmo salar*. *Aquaculture Environment Interactions* Vol. 8: 339-347.
181. Speilberg L., 2018. Stress and stress mitigation during crowding of Atlantic salmon in net-pens. *Norsk Veterinærtidsskrift* 8, 130.
182. Stich, D.S., Zydlewski, G.B., Kocik, J.F., Zydlewski, J.D., 2015. Linking behavior, physiology, and survival of Atlantic salmon smolts during estuary migration. *Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science* 7: 68-86.

183. Stien, L.H., Bracke, M.B.M., Folkedal, O., Nilsson, J., Oppedal, F., Torgerson, T., Kittilsen, S., Midtlyng, P.J., Vindas, M.A., Øverli, Ø., Kristiansen, T., 2013. Salmon Welfare Index Model (SWIM 1.0): a semantic model for overall welfare assessment of caged Atlantic salmon: review of the selected welfare indicators and model presentation. *Reviews in Aquaculture* **5**, 33-57.
184. Stien, L.H., Nilsson, J., Hevrøy, E.M., Oppedal, F., Kristiansen, T.S., Lien, A.M., Folkedal, O., 2012. Skirt around a salmon sea cage to reduce infestation of salmon lice resulted in low oxygen levels. *Aquaculture Engineering* 51, 21-25.
185. Stradmeyer, L., Metcalfe, N.B., Thorpe, J.E., 1998. Effect of food pellet shape and texture on the feeding response of juvenile Atlantic salmon. *Aquaculture* 73, 217-228.
186. Strand, D.A., Utne-Palm, A.C., Jakobsen, P.J., Braithwaite, V.A., Jensen, K.H., Salvanes, A.G.V., 2010. Enrichment promotes learning in fish. *Marine Ecology Progress Series* Vol. 412: 273-282.
187. Strom, J.F., Thorstad, E.B., Hedger, R.D., Rikardsen, A.H., 2018. Revealing the full ocean migration of individual salmon. *Animal Biotelemetry* 6:2 https://doi.org/10.1186/s40317-018-0146-2.
188. Sutherland, B.J.G., Covello, J.M., Friend, S.E., Poley, J.D., Koczka, K.W., Purcell, S.L., MacLeod, T.L., Donovan, B.R., Pino, J., González-Vecino, J.L., Gonzalez, J., Troncoso, J., Koop, B.F., Wadsworth, S.L., Fast, M.D., 2017. Host-parasite transcriptomics during immunostimulant-enhanced rejection of salmon lice (*Lepeoptheirus salmonis*) by Atlantic salmon (*Salmo salar*). *FACETS* 2: 477-495.
189. Taranger, G.L., Carillo, M., Schulz, R.W., Fontaine, P., Zanuy, S., Felip, A., Weltzien, F-A., Dufour, S., Karlsen, O., Norberg, B., Andersson, E., Hansen, T., 2010. Control of puberty in farmed fish. General and Comparitive Endocrinology 165, 483-515.
190. Tetard, S., Maire, A., Lemaire, M., De Oliveira, E., Martin, P., Courret, D., 2019. Behaviour of Atlantic salmon smolts approaching bypass under light and dark conditions: importance of fish development. *Ecological Engineering* **131**, 39-52.
191. Thorstad, E.B., Fleming, I.A., McGinnity, P., Soto, D., Wennevik, V., Whoriskey, F., 2008. Incidence and impacts of escaped farmed Atlantic salmon *Salmo salar* in nature. NINA Special Report 36, Report from the Technical Working Group on Escapes of the Salmon Aquaculture Dialogue.
192. Tørud, B., Jensen, B.B., Gåsnes, S., Grønbech, S., Gismervik, K., 2019. Animal welfare in fish hatcheries (Småfiskvel). Norwegian Veterinary Institute, Report 14, 2019.
193. Treasurer, J. & Feledi, T., 2014. The physical condition and welfare of five species of wild-caught wrasse stocked under aquaculture conditions and when stocked in Atlantic salmon, *Salmo salar*, production cages. *Journal of the World Aquaculture Society*, Vol. 45, No. 2. doi: 10.1111/jwas.12099
194. Turnbull, J., Bell, A., Adams, C., Bron, J., Huntingford, F., 2005. Stocking density and welfare of cage farmed Atlantic salmon: application of a multivariate analysis. *Aquaculture* 243, 121-132.
195. Turnbull, J.F., and Kadri, S., 2007. Safeguarding the many guises of farmed fish welfare. *Diseases of Aquatic Organisms* Vol. 75: 173-182.
196. Uglem, I., Karlsen, O., Sanchez-Jerez, P., Sæther, B-J., 2014. Impacts of wild fishes attracted to open-cage salmonid farms in Norway. *Aquaculture Environment Interactions* Vol. 6: 91-103.

197. Vilata, J., Oliva, D., Sepúlveda, M., 2014. The predation of farmed salmon by South American sea lions (*Otaria flavascens*) in southern Chile. *ICES Journal of Marine Science* 67: 475-482.
198. Vindas, M.A., Fokos, S., Pavlidis, M., Höglund, E., Dionysopoulou, S., Ebbesson, L.O.E., Papandroulakis, N., Dermon, C.R., 2018. Early life stress induces long-term changes in limbic areas of a teleost fish: the role of catecholamine systems in stress coping. *Scientific Reports* 8:5638 DOI:10.1038/s41598-018-23950-x.
199. Vindas, M.A., Folkedal, O., Kristiansen, T., Stien, L.H., Braastad, B.O., Mayer, I., Øverli, Ø., 2012. Omission of expected reward agitates Atlantic salmon (*Salmo salar*). *Animal Cognition* 15:903-911.
200. Vindas, M.A., Johansen, I.B., Folkedal, O., Höglund, E., Gorissen, M., Flik, G., Kristiansen, T.S., Øverli, Ø., 2016. Brain serotonergic activation in growth-stunted farmed salmon: adaption versus pathology. *Royal Society Open Science* **3**:160030 http://dx.doi.org/10.1098/rsos.160030.
201. Vindas, M.A., Madaro, A., Fraser, T.W.K., Höglund, E., Olsen, R.E., Kristiansen, T.S., Øverli, Ø., 2017. Uncontrollable chronic stress reduces growth disparities in farmed Atlantic salmon. *Physiology and Behavior* 179, 246-252.
202. Vindas, M.A., Madaro, A., Fraser, T.W.K., Höglund, E., Olsen, R.E., Øverli, Ø., Kristiansen, T.S., 2016. Coping with a changing environment: the effects of early life stress. *Royal Society Open Science* **3:**160382 http://dx.doi.org/10.1098/rsos.160382.
203. Vindas, M.A., Sørensen, C., Johansen, I.B., Folkedal, O., Höglund, E., Khan, U.W., Stien, L.H., Kristiansen, T.S., Braastad, B.O., Øverli, Ø., 2014. Coping with unpredictability: dopaminergic and neurotrophic responses to omission of expected reward in Atlantic salmon (*Salmo salar* L.). PLoS ONE 9(1): e85543. doi:10.1371/journal.pone.0085543.
204. Volpato, G.L., Gonçalves-de-Freitas, E., Fernandes-de-Castilho, M., 2007. Insights into the concept of fish welfare. *Diseases of Aquatic Organisms*, Vol. 75: 165-171.
205. Waagbø, R., Jørgensen, S.M., Timmerhaus, G., Breck, O., Olsvik, P.A., 2017. Short-term starvation at low temperature prior to harvest does not impact the health and acute stress response of adult Atlantic salmon. *PeerJ* 5:e3273; DOI 10.7717/peerj.3273.
206. Weir, L.K., Grant, J.W.A., 2005. Effects of aquaculture on wild fish populations: a synthesis of data. *Environmental Review* **13**: 145-168.
207. Whittaker, B.A., Consuegra, S., Garcia de Leaniz, C., 2018. Genetic and phenotypic differentiation of lumpfish (*Cyclopterus lumpus*) across the North Atlantic: implications for conservation and aquaculture. *PeerJ*, 6:e5974 http://doi.org/10.7717/peerj.5974
208. Ytrestøyl, T., Aas, T.S., Åsgård, T., 2015. Utilisation of feed resources in production of Atlantic salmon (*Salmo salar*) in Norway. *Aquaculture* 448, 365-374.
209. Yu, R., and Leung, P., 2006. Optimal partial harvesting schedule for aquaculture operations. *Marine Resource Economics* Vol. 21, 301-315.
210. Yuen, J.W., Dempster, T., Oppedal, F., Hvas, M., 2019. Physiological performance of ballan wrasse (*Labrus bergylta*) at different temperatures and its implication for cleaner fish use in salmon aquaculture. *Biological Control* 135, 117-123.

211. Zimmerman, E.W., Purchase, C.F., Fleming, I.A., 2012. Reducing the incidence of net cage biting and expression of escape-related behaviors in Atlantic cod (*Gadus morhua*) with feeding and cage enrichment. *Applied Animal Behaviour Science* 141, 71-78.