Integrated Farm Assurance

Guideline for Aquaculture

ENGLISH VERSION 6.0_SEP22

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Table A Example of EIA combined with the EMP (impacts inherent to farming operations; levels 4–7 in stages of impact assessment)

	Impact	**Applicable law**	**Working instruction**
1	Disposal of empty food bags	Municipal license	Dispose of empty food bags weekly on municipal dump
2	Discharge of sludge	E.g., province regulation on coastal protection 2003	Use settling pond; clean every two months
3	Disposal of settled sludge	Municipal license; directive on fertilizers in agriculture	200 metric tons/year of sludge can be brought to the rubber tree farms; Bring excess sludge to municipal dump
4	Use of electricity	None	Only use paddle wheels in accordance with working instruction on oxygen in ponds
5	Exhaust gases generator	E.g., government regulation 23/568 on exhaust gases	Dealer shall perform yearly check on engine adjustment
6	Pesticides for weed control	Product permits/approvals; application instructions	E.g., only use “Herbclean” once a month according to working instructions
7	Use of diesel fuel	None	Generator only uses diesel. See 4 and 5
8	Noise of the generator to surrounding neighbors	Municipal permit; agreement with neighbors	Keep doors of generator housing closed. Use ventilator at high room temperatures

Table B Example of ERA combined with the EMP (realistic risks associated with farming operations)

	Risk	Applicable law	Preventive action
1	Empty food bags blown with the wind	Municipal license	Always close the container
2	Sludge floating instead of settling; discharge into nature	E.g., province regulation on coastal protection 2003	Stop discharge and clean settling pond
3	Excessive sludge production	None	Assess pond biomass; recalculate feeding regime
4	Leakage of fluid chemicals from the storage room	Municipal license	Store all fluids on dedicated storage devices
5	Diesel spilled onto/leached into the ground	Municipal license	Store diesel in an approved tank on concrete floor; filling only under supervision

Table C Example of biodiversity impact assessment (impacts inherent to farming operations)

	Impact	Ecological consequence	Mitigation
1	Conversion of natural habitats	Loss of fish breeding ground, endangered species habitat	Consider alternative sites
2	Nutrient/organic matter/sludge release to surrounding ecosystem	Additional growth of weed and algae; oxygen depletion of bottom (dependent on tidal flow to avoid build-up of concentrations)	Settlement ponds; limiting water exchange
3	Leaching of seawater into the ground	Salinization of ground water; change in vegetation on site and downstream towards the sea	No use of ground water for ponds; yearly monitoring of surrounding ground water
4	Release of pathogens	Endangering native species	Prevention of escapes; effluent handling

Table D Example of biodiversity risk assessment and management plan (realistic risks to biodiversity associated with farming operations)

	Impact	**Ecological consequence**	**Mitigation**
1	Fish or shrimp escape	Introduction of unwanted species or pathogens threatening native species	Prefer native species; utmost precautions should be in place to prevent escapes
2	Flooding of settling pond (e.g., by storm or spring tide)	Significant change in habitat in recipient water	Dikes should be of above average height
3	Release of large quantities of chemicals	Damage to aquatic life in recipient water	Ensure adequate storage; avoid excessive chemical stocks

2 GUIDELINE AQ II – BIODIVERSITY IN ENVIRONMENTAL IMPACT ASSESSMENT[1]

Introduction

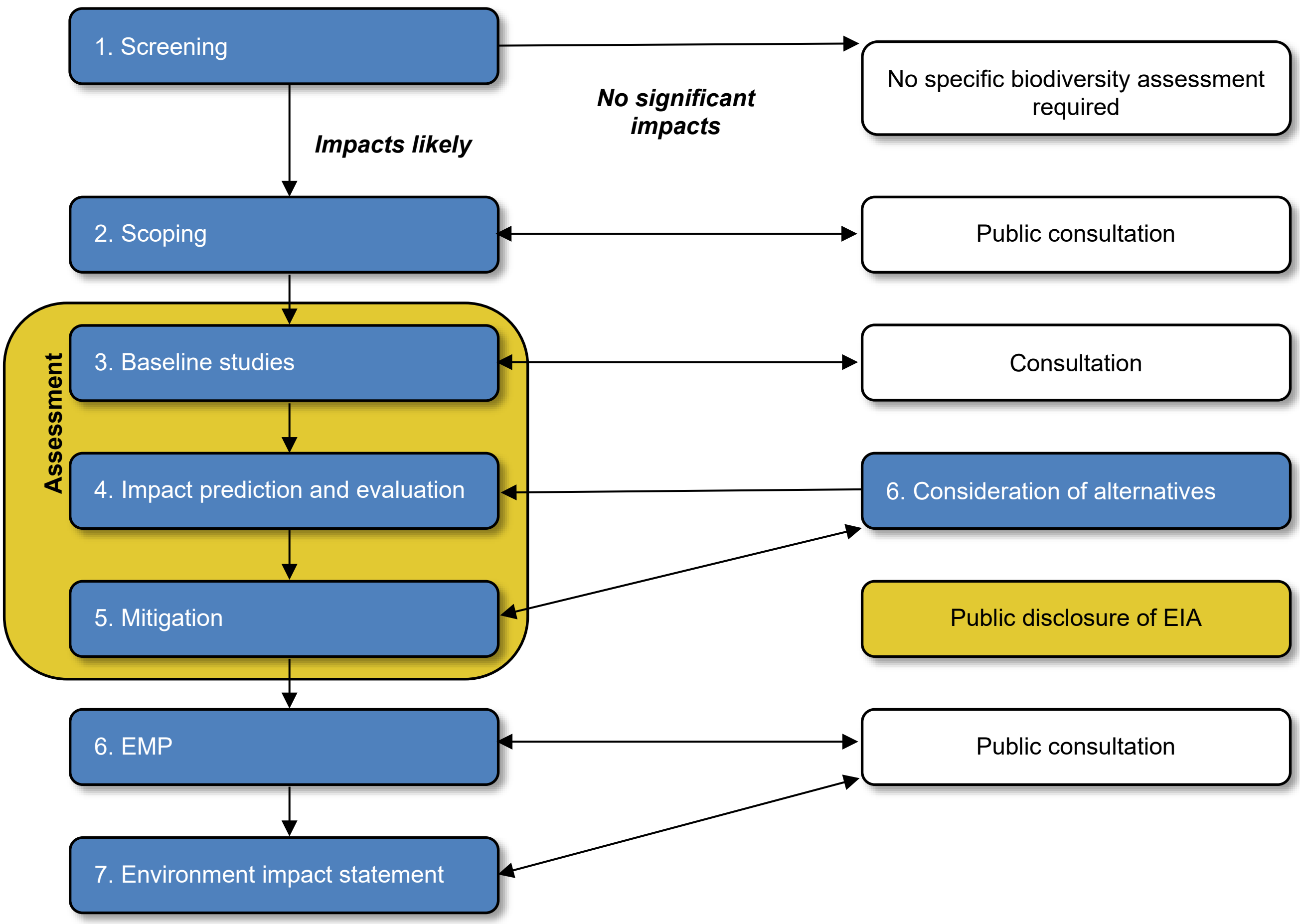
The Convention on Biological Diversity defines biodiversity as "the variability among living organisms from all sources including, amongst others, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems."

Biodiversity in more simple terms is the variety of life on earth at all levels, from genes to worldwide populations of the same species; from communities of species sharing the same small area of habitat to worldwide ecosystems.

Environmental impact assessment (EIA) provides opportunities to ensure that biodiversity values are recognized and taken into account in decision-making. Importantly, this involves a participatory approach with people who may be affected by a proposal (those living on or around the site). The participatory approach and stakeholder feedback are also key indicators as to the quality and credibility of the assessment.

[1]For key reference documents, see International Association of Impact Assessment (IAIA).

Figure A An overview of the principal stages of an EIA relevant to biodiversity



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Operating principles

1. Screening – to determine whether a proposal should be subject to an EIA or not, and if so, at what level of detail.

Use screening criteria that include biodiversity to determine whether important biodiversity resources may be affected. Biodiversity screening "triggers" for EIA should include:

- Potential impacts on protected areas and areas supporting protected species
- Impacts on other areas that are not protected but are important for biodiversity (see the following list regarding high conservation value areas)
- Activities that pose a particular threat to biodiversity (in terms of their type, magnitude, location, duration, timing, reversibility)
- Areas that provide important ecosystem services including indigenous people's territories, wetlands, fish breeding grounds, soils prone to erosion or acidification, relatively undisturbed or characteristic habitats, flood storage areas, and groundwater recharge areas, etc.

Encourage the development of a biodiversity screening map indicating important biodiversity values and ecosystem services. If possible, integrate this activity into the development of a national biodiversity strategy and action plan (NBSAP) and/or biodiversity planning at subnational levels (e.g., coastal zone management plans in regions, local authorities, towns) to identify conservation priorities and targets.

Areas of high conservation value are areas that:

- Support endemic, rare, or declining habitats/species/genotypes
- Support genotypes and species whose presence is a prerequisite for the persistence of other species
- Act as a buffer, linking habitat, or ecological corridor, or play an important part in maintaining environmental quality
- Have important seasonal uses or are critical for migration
- Support habitats, species populations, or ecosystems that are vulnerable, threatened throughout their range, and/or slow to recover
- Support particularly large or continuous areas of previously undisturbed habitat
- Act as a refuge for biodiversity during climate change, enabling the persistence and continuation of evolutionary processes
- Support biodiversity for which mitigation is difficult or its effectiveness unproven, including habitats that take a long time to develop characteristic biodiversity
- Are currently poor in biodiversity but have the potential to develop high biodiversity with appropriate intervention

2. Scoping and 3. Baseline study – to identify the issues and impacts that are likely to be important and to establish terms of reference for the EIA.

Use scoping as an opportunity to raise awareness for biodiversity concerns and discuss alternatives to avoid or minimize negative impacts on biodiversity.

It is good practice to produce a scoping report for consultation. This should address the following issues (on the basis of existing information and any preliminary surveys or discussions):

1. The type of project, program, plan, or policy, possible alternatives, and a summary of activities likely to affect biodiversity
2. An analysis of opportunities and constraints for biodiversity (include “no net biodiversity loss” or “biodiversity restoration” alternatives)
3. Expected biophysical changes (in soil, water, air, flora, fauna) resulting from proposed activities or induced by any socioeconomic changes
4. Available information on baseline conditions
5. Likely biodiversity impacts associated with the proposal in terms of composition, structure, and function
6. Biodiversity services and values identified in consultation with stakeholders and anticipated changes in these (highlight any irreversible impacts)
7. Possible measures to avoid, minimize, or compensate for significant biodiversity damage or loss, making reference to any legal requirements
8. Proposed EIA methodology and timescale

4. Impact prediction and evaluation – to determine the potential harm caused.

Address biodiversity at all appropriate levels and allow for enough survey time to take seasonal features into account. Focus on processes and services that are critical to human well-being and the integrity of ecosystems. Explain the main risks and opportunities for biodiversity.

Questions to ask:

At the gene level, to what extent will the proposal have significant effects on:

- Opportunities for species populations to interact, e.g., by increasing habitat fragmentation and isolation
- Risk of extinction

At the species level, to what extent will the proposal:

- Affect species identified as priorities in NBSAPs and/or subnational biodiversity plans (e.g., Red List species)
- Increase the risk of invasion by alien species

At the ecosystem level, to what extent will the proposal:

- Change the amount, quality, or spatial organization of habitat
- Damage ecosystem processes and services, particularly those on which local communities rely

Finally:

- If habitats will be lost or altered, are alternative habitats available to support associated species populations?
- Are there opportunities to consolidate or connect habitats?

Take an ecosystem approach and involve relevant stakeholders (including local communities). Consider the full range of factors affecting biodiversity. These include direct drivers of change associated with a proposal (e.g., land conversion and vegetation removal leading to loss of habitat – a key driver of biodiversity loss, emissions, disturbance, introduction of alien and genetically modified species, etc.) and indirect drivers of change that are harder to quantify, including demographic, economic, sociopolitical, cultural, and technological processes or interventions. Evaluate impacts of alternatives with reference to the baseline situation. Compare with thresholds and objectives for biodiversity. Use NBSAPs, subnational biodiversity plans, and other conservation reports for information and objectives. Take into account cumulative threats and impacts resulting from repeated impacts of projects of the same or different nature over space and time, and from proposed plans, programs, or policies.

5. Mitigation – to determine the framework for preventing or at least minimizing harm.

Remedial action can take several forms: Avoidance (or prevention), mitigation (including restoration and rehabilitation of sites), and compensation. Apply the "positive planning approach", in which avoidance has priority and compensation is used as a last resort. Avoid "excuse"-type compensation. Look for opportunities to positively enhance biodiversity. Acknowledge that compensation will not always be possible; there will still be cases where it is appropriate to say "no" to development proposals on grounds of irreversible damage to biodiversity.

6. Review and decision-making – to assess the suitability of the framework for harm prevention.

Where biodiversity impacts are significant, a specialist with appropriate expertise should undertake a peer review of environmental reports.

Depending on the level of confidentiality of public decision-making, consideration should be given to the involvement of affected groups and civil societies. Avoid pitting conservation goals against development goals; balance conservation with sustainable use for economically viable and socially and ecologically sustainable solutions.

For important biodiversity issues, apply the precautionary principle where information is insufficient, and the "no net loss" principle in relation to irreversible losses associated with the proposal.

7. Environmental management plan (including monitoring, evaluation, and auditing plans) – to determine how to move forward.

It is important to recognize that the prediction of biodiversity response to perturbation is uncertain, especially over the longer term. Management systems and programs, including clear management targets (or limits of acceptable change) and appropriate monitoring, should be in place to ensure that mitigation is effectively implemented, unforeseen negative effects are detected and addressed, and negative trends are identified as early and quickly as possible. Provision is made for the regular auditing of impacts on biodiversity. Provision should be made for emergency response measures and/or contingency plans where upset or accident conditions may threaten biodiversity.

8. Environmental impact statement – to provide transparency and opportunities for dialogue.

One of the most effective ways to ensure that an EIA is fair and credible is through full and public stakeholder engagement with all affected and interested parties and the public disclosure of environmental impact statements.

3 GUIDELINE AQ III – ENVIRONMENTAL PARAMETERS OF RELEVANCE BASED ON THE AQUACULTURE SYSTEM USED

When referring to the environmental impact of aquatic food production, a distinction should be made between *fed/fertilized* aquaculture and non-fed, or *extractive*, aquaculture. Examples of the latter are seaweed culture or shellfish culture: The farmed organisms are not fed and grow using the naturally available nutrients (algae/seaweed) or food (shellfish). The latter systems may still have an impact on the environment via the (human-based) operational activities, such as fuel needed for boats, engines, equipment, materials disposed of (e.g., ropes used for the shellfish lines), etc., but the farmed organisms do not generate environmental (nutrient) enrichment above natural levels. Their impact potentially alters the natural environment mainly by clearing the surrounding water of particles (causing light penetration changes), affecting the species composition of the phytoplankton in the water around the shellfish production sites, concentrating dissolved and suspended matter on the sea floor through the deposition of pseudofeces, etc.

The situation is very different in production systems using feeds or fertilizers. Most of the discharged organic matter, nitrogen, and phosphorus in these systems originates from the feed. As any animal growth process occurs with a certain degree of inefficiency, all animal food production systems, terrestrial or aquatic, produce a significant amount of waste. Mass balance studies show that typical retention rates in fish vary from 35–45% of the supplied feed carbon (C), and 30–40% and 10–16% of the feed nitrogen (N) and phosphorus (P), respectively. The remaining parts are excreted, either via feces (solid waste) or via the gills (dissolved waste). Open systems such as net enclosures or raceways, but also semi-closed systems, such as ponds with a water renewal rate of 15%/day (for example) discharge most of the excreted waste directly to the outside environment. Literature reports that for net enclosures, 40–80kg N and 3–10kg P are discharged into the environment per metric ton of fish produced. However, the impact is usually local, and effects are hardly detectable at a distance of 100–200m from the cages.

In more closed systems, such as stagnant ponds and recirculating aquaculture systems (RASs), part of the excreted waste remains within the system, where it affects the within-system ecology and water quality. For instance, solid waste may sink to the bottom of the pond, where it is converted by the local microbial community or even immobilized; dissolved nitrogen and phosphorus may be assimilated by the phytoplankton community in the pond, and so on. The advantage of RASs is that they have a semi-closed water loop, reducing the amount of discharged effluents enormously. However, in general, RASs do not immobilize waste products. Solid waste is collected and still needs to be discharged. Unless a denitrification reactor is used, nitrogen losses are converted into less toxic nitrate, which is partly discharged. To avoid eutrophication into receiving water bodies, some countries require farms with RAS to discharge their effluent into the regular sewage system, so that it can be treated in municipal wastewater treatment plants. The latter is not possible for marine farms with RAS because of the saline water.

However, taking into account the growth of aquaculture globally and the clustering of farms in certain regions, the collective amount of organic carbon, nitrogen, and phosphorus discharged by these farming activities can be significant, even when on-farm mitigation procedures are applied. Even if its local impact is not always noticeable, the sheer total volume of waste excretion by aquaculture warrants social awareness and a search for more sustainability. The local risk of the environmental impact of aquaculture depends on a complex range of factors which together may determine whether the impact is measurable, moderate, or significant.

Source: Consultancy provided by Prof. Dr. Johan Verreth, expert on ecological fish farming sustainability.

Ratio BOD_5/COD

BOD refers to the biochemical oxygen demand of microbial organisms for the biodegradation of organic matter. It is calculated from the oxygen decrease in a water sample (in a BOD bottle, kept in the dark) at 20ºC after a period of 5 days. COD additionally incorporates the chemical oxygen demand for the chemical degradation of (organic plus inorganic) products. Therefore, COD levels are always higher than BOD_5 values. The ratio BOD_5/COD helps determine the biodegradability of the waste; in wastewater treatment, a ratio below 0.4 is considered poorly degradable. As COD measurements are sensitive to salinity, following the APHA method for COD analysis in seawater is recommended. BOD is a useful indicator for the impact of farm effluent on the receiving water body, as it gives an estimation of the amount of oxygen required to oxidize the organic matter discharged via the effluent. The impact on the receiving water bodies depends not only on the concentration in the effluent, but also on the amount of water discharged per day or per week, and on the absorption capacity of the receiving water body. A confined lake or bay has a lower absorption capacity than a river with high water flow or than an open ocean environment. For example, for marine and coastal farms, the local water currents and exchange may dilute the concentrations significantly, hence the impact of the BOD_5 discharge may be limited. However, in highly protected areas, its effect may still be measurable.

	Net enclosures	**Ponds**	**RASs (incl. hatcheries)**	**Flow-through systems**
Risk of env. impact	Low	Moderate to significant	Significant	Significant
Typical values	Typical aquaculture effluents have a BOD_5 ranging between 5 and 30mg/l; if there is a risk of industrial pollution, it is wise to measure the COD as well; normally the BOD_5 is about 60–65% of the COD; a ratio below 40% indicates more chemical than organic pollution.			
Frequency	Monthly, when in full operation	At the end of the production cycle	Monthly, when in full operation	Monthly, when in full operation
Where to sample	During feeding outside the pen, and at the lowest possible part	At the outlet of the pond, or in the drainage channel	At the discharge tube	At the outlet of the tank or in the drainage channel/tube

CO_2

High levels of free CO_2 may impair the growth, health, and welfare of the farmed aquatic species, as CO_2 reduces pH and impairs the oxygen uptake capacity of the aquatic species. It can be mitigated by strong aeration or by adding sodium, magnesium, or calcium (bi)carbonate salt. Natural levels of free CO_2 range between 5 and 10/15ppm. 20ppm is considered the maximum threshold for good aquaculture water quality, yet this figure should be treated flexibly. In intensive farms, especially in RASs, it can even increase to levels of 25–40ppm. In natural water, free CO_2 is seldom a problem as it is in equilibrium with the bicarbonate/carbonate buffer system. Alkalinity is a suitable parameter for estimating the strength of this buffer system. As long as pH in the water remains above 6.5, the risk of free CO_2 levels in natural water being too high is always limited. Problems with free CO_2 occur mainly in the culture water of intensive closed production systems and need to be managed as part of the farm operation.

	Net enclosures	**Ponds**	**RASs (incl. hatcheries) and flow-through systems**
Risk of env. Impact	Low	Low	Low
Typical values	5–10ppm	CO_2 levels show diel (diurnal) fluctuations with maximum levels at sunrise and minimum levels at sunset; liming may help adjust the water alkalinity	In intensive systems where pure oxygen is added (e.g., RASs, some flow-through systems), free CO_2 levels may be elevated. Levels should not be much higher than 20–30ppm. Mitigation involves managing pH and degassing; the gas/liquid ratio in the stripping systems should preferably be around 5; CO_2 removal may increase pH; care should be taken to keep the latter under 7–7.5 to avoid ammonia accumulation to toxic levels; adding sodium or calcium carbonate can help maintain pH levels within the proper range.
Frequency	Incidentally	Incidentally	High (daily or a few times per week)
Where to sample	Inside the pen	Water column sample	RASs: in the sump tank Flow-through systems: near the outlet

H_2S

H_2S is produced by sulfuric bacteria in anaerobic conditions by reduction of sulfates. Its presence is usually related to anaerobic patches in pond sediments, in denitrification units, or anywhere else where anaerobic patches may be created (e.g., in pipes, etc.). As sulfates are more elevated in seawater (up to 2700ppm) than in freshwater (typically around 2ppm), H_2S problems occur more easily in marine farms. The production of H_2S is impaired by high oxygen or nitrate levels; high pH also reduces the concentrations, as H_2S exists in a pH-related equilibrium with HS^-. As a consequence, keeping dissolved oxygen levels in the water high is crucial to minimizing H_2S problems. Concentrations of 0.002ppm (freshwater) to 0.005ppm (seawater) can impair health and welfare. Marine species are more tolerant than freshwater species. The LC50 values for marine fish are 50–200ppm.

	Net enclosures	**Ponds**	**RASs (incl. hatcheries)**	**Flow-through systems**
Risk of env. impact	Low	Low	Low to moderate	Low
Typical values	From undetectable to 7ppm (e.g., in an anoxic area of the Black Sea)	0.1–0.2 ppm (in anaerobic patches)	25–100ppm (in anaerobic conditions)	From undetectable to 0.05ppm
Frequency	Incidentally	Incidentally	High (daily or several times per week)	Incidentally
Where to sample	Inside the pen	10cm above the bottom	In the biofilter and in the sump tank	Near the outlet

NH_4-N, NO_3-N and NO_2-N

The catabolic end product of protein utilization is ammonia, which is excreted by the fish. In water, ammonia can be taken up by algae and, if discharged, constitute a major factor causing eutrophication. For production systems in open air, total ammonia levels are limited due to assimilation by phytoplankton. In closed systems such as RASs, it is essential to convert the toxic ammonia into nitrite and subsequently to the less toxic nitrate using a nitrification bacterial reactor. Under proper conditions, nitrite concentrations will remain low while nitrate levels accumulate. In pond water or surface waters receiving farm effluents nitrate can also be absorbed by algae and thus contribute to eutrophication, but normally the absorption of ammonia by algae will reduce its availability for nitrification. In RASs, the water renewal rate (and thus discharge of effluent) is often geared to keep system nitrate-N levels below 100ppm. If a denitrification reactor is added to the RAS, nitrate can be converted into nitrogen gas, which can be stripped to the air, reducing the risk for eutrophication due to nitrogen emissions in the effluent. Based on recent scientific literature, chronic exposure to this concentration is considered safe for the health and welfare of the farmed aquatic species. However, its discharge into the environment can contribute to eutrophication. The impact of the discharge of the various dissolved inorganic nitrogen (DIN) species depends on their concentrations, on the amount of water discharged per hour, on the water flow in the receiving water body, etc. Although the discharged concentration levels may be low, the total amount of nitrogen discharged into the environment may be considerable, in particular for net enclosures and flow-through systems where no within-farm assimilation or sedimentation occurs, as only 35–40% of feed N is retained in the fish body.

	Net enclosures	**Ponds**	**RASs (incl. hatcheries)**	**Flow-through systems**
Risk of env. impact	Moderate	Moderate to significant	Significant	Significant
Typical values NH_4-N NO_2-N NO_3-N	Total DIN: 0.01–0.1ppm	0.2–10ppm 0.01–1.5ppm 0.05–5ppm	<1ppm <1ppm 60–140 ppm	1–2ppm <0.5ppm 1–5ppm
Frequency	Weekly	Weekly	At least weekly	Weekly
Where to sample	Inside the pen	Different locations in the pond; water column sample	In the sink (after nitrification reactor)	Before the outlet

PO_4^{3-}—P

In aquatic systems, phosphorus (P) appears in different forms. It can be present as any of the dissolution ions of H_3PO_4 (dissolved inorganic phosphorus (DIP)), bound to organic compounds (dissolved organic phosphorus (DOP)), present in particulate matter (particulate phosphorus (PP)) or bound to sediments. Reactive phosphate gives the amount of dissolved orthophosphate ions (PO_4^{3-}) measured in the filtrate of a water sample, poured over a 0.45µm filter. P measured in the substrate remaining on the same filter gives an estimation of the PP. Total phosphorus is analyzed after acid digestion of an unfiltered water sample by measuring the total amount of inorganic, organic, and particle-bound phosphorus (e.g., P incorporated in bacteria and plankton organisms). Reactive P is a direct measure of the eutrophication potential as the orthophosphate ions are easily taken up by algae. The majority of P in aquaculture originates from feeds (or fertilizers, where applied). As aquafeeds increasingly use plant ingredients, most of the P in these ingredients is phytate-bound and unavailable to the fish and is therefore excreted via the feces (solid waste). Studies show that at least 45–70% of the feed-P ends up in the environment. Fecal (and feed remnant) P adds to the PP complex. Depending on their physical characteristics, particles remain floating as suspended solids or settle to the bottom (in oceans, lakes, or ponds). The sediments in oceans, lakes, and ponds constitute a major sink for P, as the latter is usually immobilized in soil-based iron complexes which are insoluble in aerobic conditions and/or acid soil pH. However, these conditions may fluctuate seasonally and sediments are therefore also a source of P in the water column during reflux periods, contributing to the risk of eutrophication. In RASs and flow-through systems with a solids separator, the collected sludge may be rich in P and organic N, and, after water extraction, can be used as a fertilizer in agriculture. In RASs with a denitrification unit, however, this sludge-bound P may be released into the sump as orthophosphate ions, enriching the effluent water. Mitigation measures are not easy in cases of orthophosphate discharge. Phosphorus removal from effluents is technically possible but extremely expensive; solid-bound P can be handled via the solid waste management procedures (e.g., being used as fertilizer, see above). The impact of orthophosphate discharge into the environment ultimately depends on the size of the recipient water body, the possible dilution effect from water currents, etc.

	Net enclosures	**Ponds**	**RASs (incl. hatcheries)**	**Flow-through systems**
Risk of env. impact	Significant	Moderate	Significant	Significant
Typical values	0.005–0.1ppm PO_4^{3-}-P in the culture water	0.005–5ppm in the culture water	15–50ppm	0.10–0.15ppm
Frequency	Weekly	Bi-weekly	Monthly	Weekly
Where to sample	Inside the pen	Near the outlet; water column sample	In the sump tank	Near the outlet

Suspended solids

Suspended solids are solid particles that float in the water. Particle size can vary from less than 1μ to >100μ (microns). Particles smaller than 2μ are considered dissolved solids. Total suspended solids are measured by filtering a known volume of water over a 2μ fiberglass filter and weighing the dry substrate on this filter. Larger particles can be removed via sedimentation or by screens. Drum filters, which are commonly used in RASs, usually have screens of 60–200μm. The very small particles (<30μ) can be removed via foam fractionation. Suspended solids originate from feed remnants, feces, inorganic particles, microbial flocks, and the amount of suspended solids that enter the system via input water. The latter may be significant if, e.g., eutrophic river water is used to fill or renew ponds. To determine their environmental impact, it is important to quantify the ratio of organic vs inorganic particles in the suspended solids. Remediation can involve the use of settling tanks, screens (e.g., drum filters), or hydrocyclones (swirl separators), etc., before discharging the effluent into the open environment. These measures may reduce the suspended solid load by 60% or more.

	Net enclosures	Ponds	RASs (incl. hatcheries)	Flow-through systems
Risk of env. impact	Low (within 100m)	Moderate to significant	Moderate	Moderate to significant
Typical values	3–10mg/l	25–150mg/l	5–50mg/l	5–75mg/l
Frequency	Monthly	Monthly	Monthly	Bi-weekly
Where to sample	Underneath the pen	Near the outlet	In the effluent tube/in the sump tank	Near the outlet

Chemicals

Producing aquatic foods requires the incidental use of chemotherapeuticals (antibiotics, etc.) to combat diseases or parasites. The level of use differs strongly between production sectors and geographical areas. For example, the use of antibiotics has been reduced to nearly zero in Norwegian salmon culture but is still widespread in Chilean salmon farming. Further, chemicals are often used as antifouling agents in net pen cultures. Heavy metals may leach from equipment suspended in water. Disinfecting agents may be used to disinfect pond soils between production cycles and/or to disinfect equipment.

The risk to the environment is not necessarily high, and usually local. However, record keeping and close monitoring are warranted.

	Net enclosures	**Ponds**	**RASs (incl. hatcheries)**	**Flow-through systems**
Risk of env. impact	Low	Low	Low	Low

Glossary

BOD: Biochemical (or biological) oxygen demand

The BOD refers to the amount of dissolved oxygen consumed by a water sample (mostly due to the respiration of microorganisms and decomposition of organic compounds in the water, but also due to respiration of other organisms in the water such as zooplankton and phytoplankton) over a given period of time. Typically, this is a period of 5 days, hence the notion of BOD_5, but this period may change depending upon the amount of organic matter in the sample. To enable a proper estimation, there must be dissolved oxygen left at the end of the measuring period. As the amount of dissolved oxygen in water is limited (saturation concentration), the water sample may be diluted if the water has a high organic load.

COD: Chemical oxygen demand

The COD refers to the amount of dissolved oxygen needed to completely oxidize all organic compounds in the water. It is measured by adding potassium dichromate to an acidified water sample at boiling temperature. Typically, the procedure lasts two hours and is therefore a quicker method than analyzing BOD. As COD also includes the chemical oxidation of compounds, it is always higher than the BOD levels in the same water.

The ration between BOD and COD can be used as an indicator for the biodegradability of the organic matter in the water and is frequently used in wastewater treatment. For aquaculture plants, the higher the biodegradability of the organic matter in the effluent, the more easily it can be treated (reduced) before emitting it to the environment.

CO_2: Carbon dioxide

CO_2 is a known greenhouse gas that also dissolves in water. In water, CO_2 reacts with water to form carbonic acid (H_2CO_3) which dissociates immediately into its ionic forms HCO_3^- (bicarbonate) and CO_3^{2-} (carbonate). The molecular form under which CO_2 is prevalent in a particular body of water is highly dependent on the water pH.

Its concentration in the water seeks an equilibrium with the CO_2 in the air above the water surface. If the CO_2 in the water is above the equilibrium level, the gas will be stripped to the air. A main source of CO_2 in the water is the respiration of organisms, while algae and submerged plants may absorb it from the water during photosynthesis.

H_2S: Hydrogen sulfide

Also known as “sewer gas,” hydrogen sulfide produces a strong odor of rotten eggs, even at low concentrations. It is produced by bacteria that decompose organic matter containing sulfur. It occurs mainly in anaerobic conditions.

NH_4-N: Ammonia-nitrogen (to be distinguished from NH_4: ammonia)

The amount (moles) of nitrogen present in a particular mass of ammonium ions (often colloquially referred to as ammonia) in water. As the molar weight of the different nitrogen species in the water differs according to the ion type, referring to the molar concentration of the nitrogen atom is usually preferred to enable comparison between the different forms in which nitrogen is present.

The NH_4^+ concentration in the water is the result of ammonia (NH_3) excretion by animals on one hand and, where relevant, the uptake by algae and plants on the other hand; the extremely toxic free ammonia (NH_3) reacts with water to form the less toxic ammonium ion (NH_4^+). However, as the dissociation equilibrium of NH_3/NH_4^+ is highly dependent on pH, even relatively small amounts of NH_4^+ in water may convert into toxic NH_3 at pH levels above 7.5 to 8.

NO_2-N: Nitrite-nitrogen

The amount (moles) of nitrogen present in a particular mass of nitrite ions (NO_2^-). Nitrite is predominantly formed by bacterial conversion from ammonia in the first step of the nitrification reaction. Nitrite is highly toxic to most aquatic organisms. A bioreactor in an RAS is specifically designed to convert the toxic ammonia into the less toxic nitrate; this is a two-step reaction driven by different bacterial species; if the two reaction steps are not well balanced, nitrite may (temporarily) accumulate in the water.

NO_3-N: Nitrate-nitrogen

The amount (moles) of nitrogen present in a particular mass of nitrate ions (NO_3^-). Nitrate is predominantly produced in the final step of the nitrification of ammonia; the NO_3-N levels in the water are the result of nitrate production and its absorption by the plants/algae in the water.

DIN: Dissolved inorganic nitrogen

The total amount of dissolved inorganic nitrogen, i.e., the combined amount of NH_4-N, NO_2-N, and NO_3-N dissolved in the water.

PO_4^{3-}-P: Orthophosphate phosphorus; to be distinguished from orthophosphate

The amount (moles) of phosphorus (P) present in a particular mass of orthophosphate ions (PO_4^{3-}). Orthophosphate is one of the ions into which phosphoric acid can dissociate and the form which can be absorbed by aquatic plants/algae. For the latter reason, it is also called reactive phosphorus or soluble reactive phosphorus.

H_3PO_4: Phosphoric acid

Phosphoric acid dissociates in water:

$H_3PO_4 \leftrightarrow H_2PO_4^- \leftrightarrow HPO_4^{2-} \leftrightarrow PO_4^{3-}$. Being a weak acid, phosphoric acid does not dissociate completely, and per unit mass phosphoric acid, only a tiny amount ends up as orthophosphate ions (PO_4^{3-}). Most of the dissolved phosphorus in water will be present as H_2PO^{4-}. However, it is the orthophosphate ion that is biologically active.

DIP: Dissolved inorganic phosphorus

Although DIP is usually measured as soluble reactive phosphorus (i.e., PO_4^{3-}), it often exists as the sum of all dissociation ions of phosphoric acid. De La Rocha and Passow (Treatise on Geochemistry, 2014) mention that at common seawater pH (8), 87% of DIP consists of HPO_4^{2-} and only 12% of PO_4^{3-}.

PP: Particulate phosphorus (or particle-bound phosphorus)

Phosphorus attached to the particulate matter that remains on the filter.

4 GUIDELINE AQ IV – THE RAMSAR CONVENTION ON WETLANDS

Contracting parties in order of their accession

The “Convention on Wetlands of International Importance,” called the “Ramsar convention,” is the intergovernmental treaty that provides the framework for the conservation and wise use of wetlands and their resources. The convention was adopted in the Iranian city of Ramsar in 1971 and came into force in 1975. Since then, almost 90% of UN member states from all the world’s geographic regions have acceded to become contracting parties.

The convention’s mission is “the conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world.” Wetlands are among the most diverse and productive ecosystems. They provide essential services and supply all our fresh water. However, they continue to be degraded and converted to other uses.

The convention uses a broad definition of wetlands. It includes all lakes and rivers, underground aquifers, swamps and marshes, wet grasslands, peatlands, oases, estuaries, deltas and tidal flats, mangroves and other coastal areas, coral reefs, and all human-made sites such as fishponds, rice paddies, reservoirs, and salt pans.

Key information on each Ramsar contracting party can be found here.

A list of the contracting parties and the date on which the convention entered into force for each party can be found here.

(Source: Ramsar official website, www.ramsar.org)

5 CONTINUOUS IMPROVEMENT PLAN

5.1 Documentation of a continuous improvement plan

No process is perfect; there is always room for improvement. You as a producer are aware of the need to constantly have an eye on your products to achieve the best result. This also applies to the idea of the continuous improvement plan.

Continuous improvement means systematically identifying and mitigating waste of resources as quickly as possible and at the lowest possible cost, thus increasing efficiency. In short: continuous improvement is the consequent increase of productivity in small steps.

The process of continuous improvement includes monitoring and analyzing data. Only with relevant data can self-defined targets be planned, implemented, and verified. Such a target does not necessarily have to be a numerical value. A yes/no statement, for example on whether a particular goal has been reached, is also possible.

Within the context of the standard, the initial approach to continuous improvement is:

- Establishing a continuous improvement plan: Major Must
- Implementing the continuous improvement plan: Major Must

The continuous improvement plan identifies relevant self-defined targets and describes how progress toward each target will be monitored. The plan may include:

- Topic
- Current status with date of initial establishment of target
- Planned activity
- Planned outcome with estimated date of achievement

Once the targets documented in the continuous improvement plan have been reached, new targets are established by the producer.

5.2 Implementation of a continuous improvement plan

1It is up to you to choose the topics and activities for continuous improvement of your operation. Once a topic and activity are identified, you shall document this in your continuous improvement plan.

The continuous improvement plan shall be established for the first self-assessment and CB audit to IFA v6. The plan may cover a period of time, normally a period of three to four years, but is linked to the planned activities (can also be within one year). Within this set time, milestones (defined targets) can be defined to be able to verify whether the activities are having the intended effect.

For the first self-assessment, internal audit, and CB audit the continuous improvement plan will be established.

During the second self-assessment and CB audit to IFA v6, the initial results of the continuous improvement plan shall be presented and discussed.

The implementation of the continuous improvement plan is supported by documents and/or other objective evidence. The evidence kept on file may include:

- Actual outcome of efforts, with date of evaluation
- Comments on why the effort was successful or not successful

Once the topics in the continuous improvement plan are implemented, new topic(s) shall be identified, and a new continuous improvement plan shall be established.

If one or more of the goals identified in the continuous improvement plan are not reached, justification and description of further action shall be documented.

5.2.1 Implementation in Option 1 (individual certification)

An individual producer is allowed to implement one or more verifiable topics. These may differ per product, region, or any other factor.

5.2.2 Implementation in Option 2 (group certification)

For a producer group there are different ways of implementing the continuous improvement plan. What is important is that all producer group members be involved.

- Implementation of one or more topics at producer group level
  - Not all producer group members may be doing the same activity.
  - Activities may differ per product, region, or any other factor.
- Implementation of one or more topics at producer group member level
  - All producer group members are involved.
  - Activities may differ per product, region, or any other factor.
- Implementation of one or more topics at producer group and producer group member levels
  - All producer group members are involved either at producer group or producer group member level.

5.2.3 Plan – Do – Check – Act cycle

Careful management of this process is essential. To make sure that the integration of data and reporting in the production process's day-to-day operations is working, having a good plan and the right tools is essential.

The Plan – Do – Check – Act (PDCA) cycle is a good tool for continuous improvement.

The four steps of the PDCA cycle are:

- **Plan**: Identify an opportunity for continuous improvement in the production process. Plan how to implement the change. Write down the expected results once you have determined your course of action.
- **Do**: Implement the change on a small scale.
- **Check**: Analyze data on the results of the change and determine whether it made a difference.
- **Act**: If the change was successful, implement it on a wider scale and continuously assess the results. If this change did not work, identify another opportunity for continuous improvement and start the cycle again.

5.3 Examples

Continuous improvement can mean: *Responding, reducing, maintaining, achieving, completing, ensuring, enhancing, improving, etc.*

For example:

- Responding to complaints within a specified time frame
- Reducing the number of complaints/non-conforming products
- Improving a training program/traceability system

In the different sections of IFA v6 there is reference to topics that may be identified for the continuous improvement plan, for example the consumption of:

- Water
- Energy
- Fertilizer
- Plant protection products

For these or other topics targets can be defined, for example based on volumes. However, any other topic can be chosen. The list below is not exhaustive and only offers ideas. Other topics covered in the standard or related to the production process can also be used for the continuous improvement plan.

a) Food safety

  - Testing of products and utilities (e.g., testing for chemical residues, microbial water quality)
  - Non-conforming products
  - Postharvest washing process

b) Workers' well-being

  - Support of professional development (training)
  - Social benefits
  - Childcare
  - Improvement of social surroundings
  - Incentives for good and safe working performance

c) Biodiversity

- Buffer strips along watercourses
- Planting trees
- Retention of landscape features (walls, hedges, ponds, watercourses, or trees)
- Building new structures (stones, wood) next to farm or production areas
- Conservation of wild birds (birdhouses for birds and bats)
- Stopping invasive alien species

d) Other

- Outcome of self-assessment
- Complaint management