BAT/BEP descriptions of sustainable aquaculture in the Baltic Sea region

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1. Introduction

The 37th Meeting of the Helsinki Commission (HELCOM 37-2016) adopted the Recommendation 37/3 on Sustainable Aquaculture in the Baltic Sea region in March 2016. The Recommendation provides general guidance for the best practices for minimizing and preventing negative environmental impact of aquaculture on marine ecosystems of the Baltic Sea. Most importantly, it recommends to the Governments of the Contracting Parties to the Helsinki Convention to jointly develop Best Available Technology (BAT) and Best Environmental Practice (BEP) descriptions for sustainable and environmentally friendly aquaculture in the Baltic Sea region and to implement these. The Annex to Recommendation 37/3 provides further guidance on BAT and BEP measures aiming at sustainable aquaculture in the Baltic Sea region.

In accordance with the relevant parts of the Helsinki Convention the Contracting Parties shall apply the criteria for Best Environmental Practice and Best Available Technology described below. The term "Best Environmental Practice" is taken to mean the application of the most appropriate combination of measures. The term "Best Available Technology" is taken to mean the latest stage of development (state of the art) of processes, of facilities or of methods of operation which indicate the practical suitability of a particular measure for limiting discharges. "Best Environmental Practice" and "Best Available Technology" will change with time in the light of technological advances and economic and social factors, as well as changes in scientific knowledge and understanding. Further specifications of these definitions are included in Annex II of the Helsinki Convention.

The HELCOM Correspondence Group on Sustainable Aquaculture (CG Aquaculture) working under the HELCOM Working Group on Ecosystem-based sustainable fisheries (WG Fish), was tasked to develop a comprehensive set of BAT/BEP descriptions on sustainable marine and freshwater aquaculture for the benefit of the Baltic Sea region in 2016, taking into account the heterogeneous nature of aquaculture, variability in technology and geography with the need for a differentiated approach.

Different aquaculture systems exist, which differ in their degree and character of environmental impacts. The general properties and environmental impacts of aquaculture systems that are currently used in the Baltic Sea and its catchment area are described in Annex 1.

In general, the aquaculture sector should be encouraged to develop and to implement environmentally friendly technologies, production methods and feeds through appropriate incentives. Development and innovation towards ecologically sustainable farms and aquaculture technologies should be encouraged, including nutrient neutral and nutrient extractive ones, to avoid or minimize, and mitigate discharges of nutrients, organic matter, plastic waste, hazardous substances and handling of escapees and diseases, as relevant.

Depending on the type of aquaculture and their location, not all BAT/BEP practices described in the present document may be applicable for each production form or facility.

2. Permitting

In accordance with the national regulations/acts, a permit needs to be applied for and granted before starting aquaculture activities. Permits and regulations should be reviewed at appropriate intervals, set on a national level. When granting permits to new aquaculture facilities, and reviewing permits of existing aquaculture facilities, Recommendation 37/3 and the guidance in its Annex should be taken into account. When granting a permit for an aquaculture operation, possible cumulative nutrient inputs should be considered. In addition, the permitting procedures should consider the relevant BAT/BEP practices as contained in chapters 3 to 13 of the present document.

The compliance of aquaculture facilities and their operation in accordance with permit requirements should be verified by relevant authorities through periodic inspections.

Environmental Impact Assessments

Environmental Impact Assessments (EIA) should be conducted when the project applied for by itself or in cumulation with other projects is likely to have significant effects on the environment. The EIA should be based upon site-specific data, accompanied by appropriate modelling approaches and should focus upon near-field impacts as well as far-field impacts, covering inter alia the following aspects:

- Benthic characteristics and water quality.
- Ecological/environmental status of the water body/HELCOM sub basin¹ in which the site is located according to applicable instruments (such as the EU Water Framework Directive (WFD) and the EU Marine Strategy Framework Directive (MSFD) or pertinent legislation and policies of the Russian Federation), and HELCOM assessments.
- Prevailing surface and subsurface water current direction and velocity.
- Modelling approaches for predicting nutrient dispersion, solid deposition and the assimilative and carrying capacity of the receiving environment.

¹ Water body refers to the spatial assessment units as defined under the Water Framework Directive for the 1 nautical mile zone of the coastal waters. HELCOM sub-basin refers to HELCOM assessment units as defined for the open Baltic Sea >1 nautical mile and laid out in the HELCOM Map and Data Service, see: https://maps.helcom.fi/website/mapservice/.

3. BAT/BEP for monitoring

3.1 Background information

The requirement of conducting regular monitoring of aquaculture facilities is important to detect potential environmental impacts and to verify that the permitting requirements are followed. The data from monitoring should be made available to relevant authorities. Besides general recommendations for monitoring, recommendations for taking samples, supervision and recording are given.

3.2 General BAT/BEP on monitoring

- Monitoring that is to be carried out, should be based on a permit, national legislation or other type of authorisation given by competent national authorities.
- Monitoring should be carried out by setting up site- and facility-specific requirements.
- Where applicable, when establishing monitoring requirements, permits or authorizations should take into account the results of environmental impact assessments done for planned aquaculture projects/applications, if such have been carried out in connection to the permit in question.
- Monitoring should be carried out regularly at appropriate intervals, as laid down in the permit or other type of authorisation given by the competent national authority.
- Specific monitoring requirements should be reviewed regularly.
- When permits are reviewed, monitoring requirements may also be revised based on current knowledge and technological developments.
- Emerging environmental impacts should be taken into account by the national competent authority when reviewing specific monitoring requirements in order to identify possible contribution from the aquaculture facility.
- Monitoring requirements could consist of measurements and/or visual observations taken from across transects running in the direction of the two most predominant flows and/or modelling activities or remote sensing where applicable.
- When choosing appropriate methods for monitoring, data representativeness, data reliability and costeffectiveness for acquiring the relevant data should be taken into account.
- Monitoring of aquaculture farms should take into account the peak production or the time when the impacts are expected to be greatest (see chapter 5.1) and should allow to calculate absolute inputs.
- The monitoring requirements should aim to make the data comparable, where applicable, with other national monitoring programmes or regulations.
- Aquaculture operations in direct contact with the surrounding ecosystem (e.g., open aquaculture systems) should have monitoring requirements regarding the integrity of the equipment.

3.3 BAT/BEP for taking samples

- Water and sediment quality parameters, as well as bottom habitats and species should be measured at regular intervals and where practicable, also continuously/automatically. Samples should be taken at least annually, unless it can be demonstrated that less frequent sampling is required based on the observed effects on the environment.
- Sampling points/areas should be established in the permit or authorisation, or a separate document based on the permit, taking into account the type of aquaculture operation.

- Sample sites should be located according to the local environment where the potential impacts are
 most likely to be identified. According to the farm type, samples could be taken under facilities,
 upwards and downwards in the recipient (receiving water body) and for marine facilities also in a transect
 where possible impacts are most likely to occur. If relevant, more sampling points could be established at
 appropriate reference sites.
- The spatial distribution of sampling points of specific parameters to be measured should take into account the extent of impact.
- Sampling and monitoring should include relevant parameters such as chlorophyll a, nitrogen compounds, phosphorus compounds, biochemical oxygen demand, suspended solids, dissolved oxygen.
- Sediment quality measurements near aquaculture monitoring sites should be conducted at the same time of year, and at least biannually if relevant, coinciding with peak feeding if applicable. Where possible and relevant visual observations of the quantity and the extent of sediments could be conducted.
- Frequency of sampling should reflect the production. If the production is seasonal sampling should take place every year before production starts.
- Sediment quality sampling should include relevant parameters, such as sulphide content, redox potential, nitrogen content, phosphorus content and organic matter.
- Impact on bottom habitats and species could be monitored and assessed annually, if relevant.
- Taking into account monitoring of hazardous substances from regular environmental monitoring, additional monitoring of hazardous substances, such as veterinary medicines and antifouling agents, due to use, could be considered to assess water and/or sediment quality, if relevant.

3.4 BAT/BEP for recording and inspection

- Where applicable, data on water intake, stocking, feeding, nutrient losses, mortality, waste collection, veterinary medicines, antifouling, cleaning (including sludge removal), disinfection and harvesting should be recorded.
- Records may be kept on paper or preferably in an electronic format and monitoring results should be reported.
- Records have to be maintained for a certain period according to international standards or national legislation, preferably not less than for the period the permit or authorisation is valid.
- Results of monitoring activities should be assessed by the relevant authorities as part of their inspection and control.

4. General BAT/BEP for locating aquaculture operations in the marine environment

Taking into account maritime spatial planning, in general, locating aquaculture operations appropriately is very important in order to minimize many of aquaculture's environmental impacts. While this is true for marine as well as land-based aquaculture and freshwater aquaculture, the current chapter only focusses on marine aquaculture.

Site selection should also take into account, when relevant, the "<u>HELCOM / VASAB Baltic Sea broad scale</u> <u>marine spatial planning principles</u>" and the "<u>Guidelines for the implementation of the ecosystem-based</u> <u>approach in marine spatial planning in the Baltic Sea area</u>", as well as socio-economic aspects. This chapter is closely linked to the chapter 2 "Permitting".

Concerning marine aquaculture, it should be ensured that possible negative impacts from aquaculture will not cause deterioration or hinder the achievement of a good environmental/ecological/chemical status or favourable conservation status, as agreed upon in HELCOM and relevant national and international legislation (e.g., WFD, MSFD, the EU Habitats Directive (HD) and the EU Birds Directive (BD)). HELCOM Recommendation 37/3 and its Annex should be taken into account, including "to take full account of nutrient discharges and losses from marine aquaculture in an overall endeavour by the Contracting Parties to keep inputs within Maximum Allowable Inputs² for nitrogen and phosphorus for the Baltic Sea basins, as agreed at the 2013 HELCOM Copenhagen Ministerial Meeting and in its possible future updates".

In addition, and to support this, the following BAT/BEP apply:

- In case deterioration of the ecological/chemical status would occur due to the establishment of new intensive finfish production or renewal of existing permits, or if the achievement or maintaining of a good ecological/chemical status under the WFD or other nationally applicable instruments, or good status with respect to eutrophication/hazardous substances based on assessments and as classified by HELCOM or under the MSFD, or other nationally applicable instruments, is compromised, such establishment should not be authorised in such a location.
- Concerning nutrient discharges, the following should be considered for marine aquaculture together
 with all other sectors and nutrient sources: the basin-specific maximum allowable inputs (MAI) and
 national nutrient input ceilings (NICs) as laid down for nitrogen and phosphorus in the updated Baltic
 Sea Action Plan should be taken into account, including the commitment of HELCOM Contracting
 Parties to follow the precautionary principle and "to avoid increasing nitrogen and phosphorus inputs
 to a basin to the extent possible until both MAI and good status with respect to eutrophication have
 been reached, even in basins where inputs are already below the NIC".
- The current speeds of the area should be sufficient to prevent excessive accumulation of organic matter yet not higher than what can support optimal growth and feed conversion rate (FCR), maintenance of good fish welfare and the integrity of the farming infrastructure.
- For mussel cultivation, the current speed should not surpass that at which mussels are capable of settling and intercepting food items.
- .For finfish and suspended shellfish cultivations, a minimum water depth in combination with sufficient flow rate should be considered to help minimise localised accumulation of solid waste upon the benthic zone below the respective aquaculture facilities.
- Site selection should take the assimilative capacity or carrying capacity of the environment into account, which is defined as the amount of pollutants that can be discharged without causing

² <u>https://helcom.fi/baltic-sea-action-plan/nutrient-reduction-scheme/maximum-allowable-inputs/</u>

concentrations in water, sediment and biota not in compliance with thresholds under applicable instruments such as WFD, MSFD and HELCOM.

- Site selection could be supported by modelling approaches that predict nutrient dispersion, solid deposition and the assimilative and carrying capacity of the receiving environment.
- Site selection could further be supported by using hydrodynamic and ecological modelling that allows a prediction about the area of potential impact, considering both near-field and far-field impacts.
- Regional planning may be employed as an instrument for directing fish farming activities to suitable areas and mitigating conflicts between fish farming and other uses of the water area.
- New fish farms should not be allowed in protected areas if they compromise species and habitat protection or conservation objectives for which MPAs and Natura 2000 sites have been established.

Potential negative impact of aquaculture operations located outside protected areas on species and habitat protection and on these protected areas or other ecologically sensitive areas, should be assessed and avoided as agreed upon in relevant national and international legislation.

5. BAT/BEP for reducing negative effects of nutrient discharges from aquaculture

Setting overall maximum allowable discharge limits for nitrogen and phosphorus (in kg or tonnes) at farm level is an effective tool to ensure that the actual nutrients emitted from each individual fish farm do not harm the local environment and to e.g., take into account the country specific NICs. The fish farmers may produce more, as long as the maximum allowable discharge limits are not exceeded. Therefore, incorporating these maximum discharge limits in permitting and in planning, if applicable, is recommended (cf. Chapter 2).

Furthermore, discharge limits for nitrogen or phosphorous per live weight (in kg or tonnes) of fish produced, such as used in HELCOM Recommendation 25/4, can be a useful tool to ensure a minimum nutrient efficiency in aquaculture production.

These two tools of controlling discharges can thereby in conjunction help to both limit discharges on a national level by setting overall maximum allowable discharge limits and ensure a minimum nutrient efficiency at farm level by applying average discharge limits per kg fish produced.

While the two tools described above are appropriate to manage nutrient discharges from aquaculture systems at farm level, they can per se not avoid cumulative impacts. Discharges arise from aquaculture but mainly from diffuse and point sources from all sectors on land and at sea, including internal loading which may lead to excessive nutrient inputs. These cumulative discharges should be considered for aquaculture together with all other sectors and nutrient sources in the permitting process (c.f. Chapter 2).

5.1 Recommendations for discharge limits for nitrogen and phosphorus

Concerning the discharge limits of nitrogen and phosphorous, the following BAT/BEP applies for open marine aquaculture systems and land-based or closed systems

- Aquaculture operations that are subject to permitting and where fish are fed should have maximum allowable discharge limits for nitrogen and phosphorus (in kg or tonnes per year) or maximum allowable annual use of N and P in feed set at farm level.
- Additionally, a maximum discharge limit for nitrogen and phosphorous per kg of produced fish may be set in order to ensure efficiency of production.
- These discharge limits should constitute an essential part of the permitting regime and should be incorporated in the licencing process.
- Farms are required to report to the competent authority on the amount of nitrogen and phosphorus discharged or used in the feed on a regular basis (preferably annually).

5.2 Recommendations for open marine aquaculture systems

5.2.1 Open cages

Open cage systems cause reasons for concern regarding nutrient discharges since they have no physical barrier to prevent nutrients from being emitted directly into the surrounding environment and the amount of nutrients discharged can only be controlled via the biomass of fish cultured and/or the amount of feed used. Therefore, site selection as outlined in chapter 4, and setting discharge limits for nitrogen and phosphorus as outlined in chapter 5.1.1. are important to minimize nutrient losses from aquaculture facilities.

5.2.2 Extractive aquaculture and multi-trophic aquaculture

Through extractive aquaculture, nutrients are removed from the water. Nevertheless, such aquaculture is not without impacts. When mussels are farmed, they excrete faeces and pseudofaeces that can accumulate underneath the farm and can cause organic enrichment and oxygen depletion in bottom sediments. To limit such impacts, the following BAT/BEP apply:

- Concerning mussel farming, stocking densities of mussels need to consider the assimilative capacity of the marine environment.
- Models could help in determining the assimilative capacity of the environment as well as further environmental impacts of mussel aquaculture.
- Suspended mussel culture systems should be designed in order to minimize loss of mussels falling to the bottom.
- Environmental monitoring of the impacts on benthic habitats should be carried out.

Nutrient extracting species, such as mussels and seaweeds, may be used to extract or address the nutrient inputs of finfish aquaculture. However, using extractive species as compensatory measures is still to be recognised as BAT/BEP. Integrated multi-trophic aquaculture (IMTA) combining the cultivation of organisms from different trophic levels can be effective in reducing nutrient inputs but fully addressing the nutrient discharges from finfish aquaculture is difficult to achieve. The technical and economic performance of IMTA systems in the Baltic Sea needs further evaluation.

5.3 Recommendations for land-based or closed aquaculture systems

5.3.1 Recirculating aquaculture systems

RAS allows for a high degree of recirculation of water and treatment of effluent water. BAT/BEP is mainly focused on water treatment and sludge handling. To reduce environmental impacts of RAS the following BAT/BEP apply:

- Feeding could be optimised by using feeds purposely developed for use in RAS to reduce nutrient discharges (see also chapter 5).
- Effluent water of RAS should be treated on site by appropriate treatment technologies or in a nearby wastewater plant.
- Sludge of RAS should be treated on site by effective water treatment systems or sedimentation, constructed wetlands could be used as settling ponds.
- Sludge from RAS may be used as fertiliser, provided that it complies with applicable regulations for fertilizers, or be used in a biogas plant.

5.3.2 Flow-through tanks and pond systems

For these systems, the following BAT/BEP apply:

- Water discharged from newly established flow-through systems should be treated by suitable water treatment processes. For already established systems, such treatment processes should be implemented if feasible.
- Sludge from flow-through and pond systems may be used as fertiliser, provided that it complies with applicable regulations for fertilizers, or be used in a biogas plant.

Development and intensification of freshwater pond-based aquaculture could include IMTA-like production.

5.4 Waste management practices

Aquaculture activities, such as farming, slaughtering, and processing, produce 'biowastes'. Such waste may be a source of organic matter pollution and be a vector for diseases if not handled properly.

BAT/BEP is defined in the following for mortality management, aquaculture processing wastes and sludge underneath open cage farms.

5.4.1. Mortality management

Besides nutrient emissions from fish metabolism and uneaten feed leftovers, mortality is the principal biowaste generated by fish farms. The following BAT/BEP apply:

- Dead and moribund fish should be collected from the cages daily, taking into account force majeure cases, to reduce predator attraction and prevent the spread of pathogens, both within the aquaculture and the natural environment.
- Dead fish from marine fish farms should be transported to shore for proper land-based treatment.
- Dead fish should be stored and treated properly and transported to proper disposal when needed. If dead fish cannot be removed immediately from site and transported to a treatment facility, ensiling or freezing is preferable, both as a method of storage and partial inactivation of pathogens.
- In net-cage cultivation, the net should be designed or managed to facilitate the collection of dead fish when possible and feasible. Mortality collection systems should be installed to facilitate, when possible and feasible, the regular removal of dead fish and reduce dependency upon divers.
- The volume of mortality should be recorded and all stored and transported dead fish should be clearly registered (including information on the date when the dead fish are put into storage, the destination, date of collection and relevant details of the receiving entity).

5.4.2. Wastes from on-farm processing of aquaculture products

Another source of biowaste is the processing of aquaculture products, if done on-farm. When economically and logistically practical, and when regulations allow, aquaculture processing by-products should be utilised or otherwise valorised, rather than disposed.

The following BAT/BEP apply:

- Primary (including slaughtering) and secondary processing (filleting or otherwise cutting the fish), causing discharges of organic matter should not take place at sea, either upon or adjacent to sea-based farm sites.
- Water discharges from processing should be monitored and recorded frequently and should have minimal solid and dissolved nutrient wastes and have an acceptable biological and chemical oxygen demand.
- Discharges should have characteristics that do not exceed the assimilative capacity of the environment.
- Processing wastes should be managed depending upon the case specific characteristics of waste and wastewater produced (e.g., flocculation and coagulation, or flotation methods should be employed to remove fats and oils, use of ozonation to inactive pathogens, biological filtration to remove solid and dissolved nutrients).

5.4.3. Sludge management for open cage farms

Sludge containing nutrients and hazardous substances can accumulate underneath open cage farms in the marine and freshwater environment. Sludge accumulation can be minimised by placing open cage farms in areas with adequate current speeds.

Collection of organic matter materials in net cage finfish farming is, at present, not yet a possibility for offshore aquaculture operations but could have more potential for near-shore or coastal operations. Methods for sludge removal in the water phase at fish farms are being developed and may be introduced so as to decrease the discharges of nutrients, organic matter and chemicals. Sludge that accumulates underneath farms should be removed regularly if this is permitted by legislation and is proven to have environmental benefits.

Appropriate fallowing periods could generally reduce the effect of accumulation of sludge underneath open cage farms and could also minimize diseases at site. In many regions, the harsh winter conditions act as a "natural" fallowing period. Considering fallowing, it is therefore recommended to:

• Implement fallowing periods when it is shown to have environmental benefits.

6. Recommendations for fish feed type, composition and feeding practices

Fish feed type, composition and feeding practices are important factors for a sustainable aquaculture. Fish feed in general should promote good health and fish well-being, thereby reducing the need for the use of veterinary medicinal products. Furthermore, a basic knowledge of aquaculture feed and feeding strategies is important for understanding how nutrient emissions from aquaculture can be minimised. Fish feed type and feeding methods influence the amount of feed that is offered to fish, the amount of feed remaining uneaten, and the proportion of nutrients within the feed that are undigested and ejected as waste. To minimize nutrient discharges to the Baltic Sea, feed formulations should be optimized according to nutritive requirements and in order to improve retention of nutrients and bFCR³. The aquaculture sector should generally be encouraged to apply environmentally friendly feed and feeding strategies through appropriate incentives.

BAT/BEP is defined in the following for feeding strategies, fish feed type, composition and fish feeding practices and sustainable sourcing of feed.

6.1 Feeding strategies

Feed inputs to intensive aquaculture systems are a major part of the total cost of production, so there is an economic incentive for farmers to increase the efficiency of feed use. FCR is a standard parameter for quantifying feeding efficiency in aquaculture production. The aim for aquaculture operators should be to obtain a bFCR and eFCR⁴ as low as possible, while considering aspects of the economic viability of aquaculture operations, as well as e.g., animal welfare, quality, environment and climate impact and the availability of ingredients. As a supplement to maximum nutrient discharge limits and nutrient effectivity (c.f. Chapters 5.1.1, and 5.2.1), a guiding FCR can be set up.

6.2 Fish feed type and composition

The following BAT/BEP apply:

- Optimized feed formulations should be used in order to improve retention of nutrients and bFCR.
- Only compound quality feeds should be used, with formulations that are easily digestible and have a
 nutrient profile that supports maximum retention efficiency in fish. Forage fish that are fed directly to
 carnivorous aquaculture species, and moist feeds, that are handmade or manufactured at the farm,
 should be avoided unless there are no alternatives, e.g. in connection with new farmed species or
 specific life stages for which such formulations are not yet available.
- Where available, feeds should be specific to the species being cultivated and the size/life stage of the stock.
- Fish stocks should be uniform in size to improve the accuracy of size specific feed types and feeding regimes.
- Periodic grading should where applicable be used to enable the sorting of fish into cohorts of similar sized individuals to achieve an optimal FCR.

6.3 Fish feeding practices

The following BAT/BEP apply:

- Feed should be stored within an appropriate environment with suitable levels of humidity and temperature, to ensure that nutritional quality and palatability are maintained.
- Feed bags should not be left open and unattended on fish farms.

 $^{^{3}}$ A Feed Conversion Ratio FCR is a measure of the amount of feed used to produce an amount of fish. For example, if 1.25 kg of feed is used to produce 1 kg of fish, the feed conversion ratio is 1.25: 1, or simple 1.25. Biological FCR is the quantity of feed consumed that is converted to fish mass.

⁴ Economic FCR is biological FCR plus the quantity of feed consumed by fish that are eventually lost through mortality, and the quantity of feed remaining uneaten.

- Feeding practises should be made by knowledgeable and experienced staff; while the tables provided by feed manufacturers which estimate the quantities of feed required for optimal FCR and growth rate should be followed if relevant, informed adjustments to feeding quantity and rate may be necessary.
- Feed quantity should be determined considering parameters such as temperature and oxygen concentration of the water as well as weather conditions and ocean currents.
- Automated feeding systems could be used if they improve feeding efficiency and reduce waste.
- Automated feeding systems could be equipped with underwater video technology if this improves feeding efficiency, enabling observation of feed pellet and fish feeding behaviour.
- Appropriate methods and techniques should be applied for detecting uneaten feed and to optimise when to stop feeding.

Integrated feeding and monitoring systems are still under development, and they may have the potential to enhance the efficiency of feeding regimes.

6.4 Sustainable sourcing of feed

Aquaculture operators should give preference to environmentally friendly feeds sourced from a sustainable origin. In making aquaculture more sustainable, an important step is the reduction of the amount of wild fish in fish feed and the replacement by alternative ingredients, for instance by mussel meal or fish trimmings. If fishmeal and fish-oil are used as ingredients in the feed of farmed fish species, the aquaculture operator should give preference to environmentally friendly feeds, for instance feeds that are produced using sustainably sourced raw materials, such as non-food grade materials.

The use of regionally sourced products as fish feed ingredients should be encouraged.

7. BAT/BEP to avoid or minimise hazardous substances pollution

Aquaculture operations can be a source of hazardous substances inputs. Veterinary medicinal products, antifouling coatings, and cleaning and disinfection products can contain hazardous substances which can make their way into the environment. In accordance with Recommendation 31E/1, HELCOM's objective with regard to hazardous substances is to prevent pollution of the Convention Area by continuously reducing discharges, emissions and losses of hazardous substances, with the ultimate aim of concentrations in the environment near background values for naturally occurring substances and close to zero for man-made synthetic substances.

As part of the 2021 HELCOM Baltic Sea Action Plan (BSAP), it has been agreed that the HELCOM 2021 Baltic Sea Action Plan (BSAP) goal on hazardous substances is a Baltic Sea unaffected by hazardous substances. Especially toxic, bioaccumulative and persistent substances as well as endocrine disruptive substances are of concern. BAT/BEP should therefore aim to avoid pollution from hazardous substances. The 2021 BSAP includes specific measures with regard to pharmaceuticals and biocides.

Before the use of pharmaceutical and biocidal substances it is therefore generally recommended to consider information about the environmental impact (occurrence, fate, and effect data) which will e.g., be established according to action HL22 of the 2021 BSAP.

The recommended BAT/BEP below apply to both open marine aquaculture systems and land-based systems.

7.1 Veterinary medicinal products

The BAT/BEP for the use of veterinary medicinal products in aquaculture is always to utilise preventive methods first, also including vaccines. Vaccinations are an effective preventive measure utilised in aquaculture. In the Baltic Sea region, vaccines are available for fin fish such as salmon and trout. Other veterinary medicinal products should only be used as a last resort. Where it is necessary to use veterinary medicinal products, those with the lowest risk for the environment and species should be used, depending on their environmental properties.

Biosecurity refers to measures aiming at preventing the introduction and/or spread of diseases and therefore reduces the use of veterinary medicinal products. A biosecurity plan based on the principles below could be considered and prepared by the operator.

Best preventive methods depend on the species of fish being cultured and the production system being used.

The following BAT/BEP apply:

Preventive health management

- Stress experienced by the individual fish may increase the susceptibility to diseases. Any applicable management practises that reduce stress for the individual fish should be applied.
- Ensure water quality control parameters such as dissolved oxygen, salinity, temperature, pH, and the amount of water flow.
- Stock only healthy fish (without signs of disease) at correct densities (varies by species and size) in the first instance reducing the likelihood of infections.
- Hygiene procedures should be carried out to minimise the risk of infection, such as net washing and drying when relevant, removing mortalities, and ensuring feed is stored and disposed of correctly if it gets contaminated or becomes mouldy or stale.
- When necessary, use approved vaccines, or vaccines that are produced according to good manufacturing practice (GMP) and are used according to national legislation, against relevant diseases.
- No prophylactic use of antimicrobial medicinal products.

• Treatment water from vaccination baths from land-based facilities should not be directly discharged into the surrounding environment but disposed of properly or treated adequately.

Treatments

- Only use medicines as they are prescribed, in the correct treatment dosage and frequency and with the correct application method.
- Do not use pharmaceutical substances which are persistent, bioaccumulative and toxic (PBT) or very persistent and very bioaccumulative (vPvB), as far as information is available.
- If antibiotics are used, only those approved for in-feed administration, should be used.
- Aim to minimize any losses of medicines into the environment during administration.
- For significant health problems that arise seasonally, a treatment strategy should be developed.
- Regional coordination is recommended in areas where aquaculture is taking place and could prove effective, especially in the case of contagious infections. Farms which could affect each other should communicate any relevant incidences of diseases or parasites and co-ordinate their treatments.
- Unused or expired veterinary medicines should be disposed of properly, according to national legislation.

7.2 Antifouling

The 2021 BSAP aims at minimizing the release of biocides from antifouling products to the marine environment. Preferably by 2027 the use of biocidal antifouling products should be replaced with biocide-free antifouling strategies among others on structures and equipment, when available and environmentally and technically feasible (BSAP action HL30). Knowledge about the local (and regional) biofouling species community is essential for establishing an effective and appropriate antifouling strategy, keeping in mind that efficacy studies might not be designed to reflect Baltic Sea conditions. Therefore, a qualified monitoring and assessment of biofouling should be considered.

Biocide-free antifouling strategies

Biofouling is usually lower in low salinity areas of the Baltic Sea. Qualified assessment of the situation is important to ensure effective antifouling. Biocide-free antifouling strategies should be aimed at ensuring that the materials and processes used are environmentally compatible and efficient.

Biocide-free antifouling strategies should be applied with the purpose of supplementing and in due time substituting biocidal antifouling agents. The following biocide-free antifouling measures should be considered as supplementing and substituting biocidal antifouling agents as appropriate in accordance with the local conditions:

- Periodical drying of the nets on land should be considered as part of a biocide-free antifouling strategy.
- Alternative net types/materials and processes should have proof of efficacy. It is important that they do not have adverse effects on the marine environment e.g., input of micro plastic.
- Consideration could be given to the selection of the colour of nets depending on the presence of fouling species⁵.
- Cleaning of nets and equipment or structures should be done on land if feasible. On land cleaning sites should have suitable effluent treatment or collecting systems in place. Resulting waste should be collected and disposed of appropriately.

⁵ Finlay, J.A.; Fletcher, B.R., Callow, M.E.; Callow, J.A. (2008): Effect of background colour on growth and adhesion strength of Ulva sporelings. In: Biofouling, 24, p. 219-25. Available at: <u>https://pubmed.ncbi.nlm.nih.gov/18386189/</u>

- In situ cleaning should be possible when cleaning is necessary during production and non-biocidal antifouling products are used.
- Non-biocidal antifouling products should not contain hazardous substances (ref. HELCOM Recommendation 31E/1).
- Instructions for use and risk mitigation measures should be implemented, where relevant.
- Disposal of unused chemicals should be done according to applicable national regulations.

Biocidal antifouling strategies

The following BAT/BEP apply:

- Biocidal antifouling strategies should be applied only when necessary. Biocidal antifouling products should comply with the applicable instruments, such as regulation (EU) Nr. 528/2012 (Biocidal Products Regulation) for those Contracting Parties that are also EU Member States and should be either (a) authorized or (b) transnationally marketable in accordance with the BPR transition rules of the respective Contractive Party.
- Choose the appropriate product for the local situation and intended use.
- Choose a product with a biocide concentration appropriate to the local fouling conditions.
- Instructions for use and risk mitigation measures specified as part of the authorisation of biocidal products should be implemented.
- Reduce the frequency of new application of anti-fouling products. Reimpregnate nets only when necessary but not more often than specified for the biocidal antifouling product.
- Unused or expired biocidal antifouling products should be disposed of properly, according to national legislation.
- Cleaning of nets and other equipment or structures should be done on land. In situ mechanical cleaning should not take place. On land cleaning sites should have suitable effluent treatment or collecting systems in place. Resulting wastes are to be collected and disposed of appropriately.
- Nets and other infrastructures coated with biocidal antifouling products should be stored and disposed of properly according to national legislation or relevant guidance.

7.3 Cleaning and disinfection agents

To reduce environmental impact BAT/BEP should be implemented during storage, use and disposal of agents. In general, using cleaning and disinfection agents should be thought of, and they should not be used unless needed. Non-chemical solutions should be considered and preferred if available. When selecting chemical agents, it is important to choose products which are suitable for the intended use to ensure their effectiveness and thus avoid unnecessary use. Cleaning agents and disinfectants should be used only according to the applicable legal regulations and by properly qualified staff.

In the European Union, only biocidal products of product type 3 (disinfections for veterinary hygiene) that are registered by national authorities and marketable in accordance with the EU Biocidal Products Regulation (BPR, Regulation (EU) No 528/2012) transitional rules, or authorised according to the BPR in the respective country for the intended use should be used for disinfection purpose.

The following BAT/BEP apply:

- Use suitable disinfectant agents for intended use.
- Only disinfectant agents that are legally registered should be used.

- Disinfectant agents should have no or minimal impact on the environment and should be readily biodegradable without hazardous degradation products as far as possible.
- Biocidal products classified according to CLP Regulation (EC) 1272/2008 as H400 "very toxic to aquatic organisms" and H410/H411 "very toxic to aquatic organisms with long lasting effects" should be avoided and replaced by products with less hazardous properties as far as possible.
- Legally binding instructions for use and risk mitigation measures are specified as part of the authorisation of biocidal products and should be implemented.
- Surfactants in cleaning products should be biodegradable.
- Appropriate application method and dosage, amount or concentration as specified on the label should be used.
- Potential residues of cleaning and disinfectant agents on surfaces should be avoided.
- Precautions should be taken to prevent spills. Procedures and containment plans should be in place for managing spills of cleaning and disinfection agents. Supplies needed for cleaning up spills should be available.
- Manufacturer's instructions for emergency measures to protect the environment should be followed.

Storage and disposal of cleaning and disinfection agents and empty containers should be done according to applicable national regulations.

8. BAT/BEP to avoid plastic waste from aquaculture

Appropriate practices and technologies for plastic waste prevention and removal should be implemented whilst observing due compliance with applicable instruments, such as the EU Strategy for Plastics in the Circular Economy, and EU legal provisions such as the Marine Strategy Framework Directive (MSFD, 2008/56/EC) and the Directive on the reduction of the impact of certain plastic products on the environment (Single-Use-Plastics Directive, 2019/904). When applicable, also regional and national action plans on marine litter and other relevant documents including research results to provide more tailor-made measures for the aquaculture sector, also for individual HELCOM Contracting Parties, should be in accordance with the relevant practices and technologies for plastic waste prevention.

The overall objectives should be to reuse and recycle, repair, and recover any plastics derived from aquaculture. BAT and BEP for prevention, mitigation and remediation can be applied and achieved with the aim towards reduction of plastics applied in and released into the environment from aquaculture operations. The Contracting Parties are conducting regular monitoring of plastic pollution pathways, hotspots and quantification (such as project BLASTIC) through effective implementation of the methods in the HELCOM <u>Guidelines for monitoring beach litter</u> and the <u>HELCOM Guidelines on monitoring of microlitter in seabed</u> sediments in the Baltic Sea. If monitoring programs or dedicated research indicates that aquaculture derived litter is a problem, the source of the litter should be addressed and, if needed, clean up should be conducted.

Greater efforts should be made to reduce and avoid plastic waste through applying the following BAT/BEP:

- Each aquaculture facility should aim to reduce the use of unnecessary single-use plastic items, such as packaging.
- Collection targets should be set for end-of-life aquaculture fishing gear containing plastics and extended producer responsibility (EPR) schemes applied for aquaculture fishing gear containing plastics brought to the market.
- Making use of incentives from existing regional or national funding programmes for aquaculture producers to motivate them to invest in more durable, easy to recycle, repairable materials/items and alternative solutions.
- Equipment design and materials with the least environmental impact should be used.
- When the equipment is still being used, maintenance and timely repair of aquaculture equipment should be undertaken by aquaculture producers.
- Appropriate waste handling practices, in particular related to plastic waste, should be in place.

- 1. FAO 2017 Microplastics in fisheries and aquaculture Status of knowledge on their occurrence and implications for aquatic organisms and food safety. Prepared by Amy Lusher, Peter Hollman, Jeremy Mendoza-Hill. FAO Fisheries and Aquaculture Technical Paper no 615.
- 2. Marelitt Baltic Poject 2016-2019. The Baltic Sea Blueprint. A step by step roadmap on how to approach Derelict Fishing Gear. Prepared by Vesa Tschernij et al. https://interreg-baltic.eu/wp-content/uploads/2021/10/26-MARELITT_Baltic_Sea_Blueprint.pdf
- 3. BLASTIC (Plastic Waste Pathways into the Baltic Sea) EU Interreg Central Baltic 2016-2018. http://database.centralbaltic.eu/sites/default/files/BLASTIC_FINAL_report%281%29.pdf
- 4. European Union 2019 Circular economy in fisheries and aquaculture areas. Prepared by Monica Veronesi Burch, Arthur Rigaud; Thomas Binet & Clara Barthélemy, Vertigo Lab, Farnet Guide #17.
- 5. Global Ghost Gear Initiative (2021) Best Practice Framework for the Management of Aquaculture Gear. Prepared by Huntington, T. of Poseidon Aquatic Resources Management Ltd. for GGGI. 81 pp. plus appendices.

- 6. Floerl O., Sunde L.M., Bloecher N.; 2016 Potential environmental risks associated with biofouling management in salmon aquaculture, Aquaculture Environment Interactions, Vol. 8: 407–417.
- Skurtun, M., Sandra M., Strietmnan W.J., van den Burg S. W. K., De Raedemaecker F., Devriese L. I.;
 2022 Plastic pollution pathways from marine aquaculture practices and potential solutions for the North-East Atlantic region, Marine Pollution Bulletin Volume 174, January 2022, 133178

9. BAT/BEP on species, preventing escapees and risk management

The Baltic Sea brackish water ecosystem is highly sensitive to the introduction of invasive non-indigenous species, the introduction of which is typically irreversible. Invasive non-indigenous species has for long been a dedicated topic in HELCOM and the BSAP includes a management objective of "No introductions of nonindigenous species". Relevant BSAP actions related to non-indigenous species prevention have been adopted and monitoring of non-indigenous species is in place following the HELCOM Guidelines for monitoring nonnative species. A strict approach is motivated and in open cage aquaculture there is a zero tolerance of using such known invasive non-indigenous species and precautionary approach for potentially invasive nonindigenous species. The use of non-indigenous but previously farmed fish species such as rainbow trout, that are exempted from EU regulation 708/2007, should be treated with proper consideration⁶. Escapees of nonindigenous fish species from aquaculture may pose a threat in relation to indigenous fish species such as outcompeting native species for food or other resources, interbreeding, destruction of spawning grounds, spreading of diseases or killing young individuals of the indigenous species. The definitions in EU regulations 708/2007 and 1143/2014 regarding non-indigenous species, invasive non-indigenous species and locally absent species are used in this chapter. The following instruments have been taken into account in drafting this chapter: Regulation (EC) No 708/2007 (1), ICES CoP (2), Regulation EU 1143/2014 (3), CBD Article 8(h) (4), CBD Decision VI/23 (5) and Aquaculture Code of Practice (6).

To mitigate the escapees of non-indigenous species from aquaculture the following BAT/BEP apply:

- Non-indigenous species are not allowed to be used in aquaculture when the risk assessment shows a risk to the environment greater than "low" in accordance with Regulation EC 708/2007 and unless they are explicitly allowed in Annex IV of Regulation EC 708/2007.
- Selection and use of locally absent species should take place under documented conditions and be subject to control that varies according to the organism in question and rearing conditions. As necessary, the locally absent species should be placed under quarantine for sufficient period of time, as described in Annex III of Regulation (EC) No 708/2007⁵.
- Species selection should aim to avoid the risk of genetic pollution of local fish populations and risk of transfer and spread of disease and parasites with particular consideration of the native salmonid stocks of the Baltic Sea and its catchment area.⁴
- Introduction of any species other than those mentioned in Annex IV of Regulation 708/2007 requires a permit in accordance with Regulation 708/2007.
- Due to the transboundary nature of the risk to spreading species (including the spreading of reproductive stages e.g., eggs, larvae, spores), diseases and parasites, open sharing between the Contracting Parties of the risk assessments could take place prior to any introduction of new species into aquaculture within the Baltic Sea and its catchment area.
- All aquaculture operations in direct contact with the surrounding ecosystem (e.g., open cage aquaculture) should strive for zero escapees by implementing the following:
 - escape prevention measures
 - using farming equipment that is 1) fit for purpose and 2) inspected regularly, maintained, and repaired according to a documented procedure for the farm in question and/or when necessary.
 - using suitable construction to withstand the local weather and climate conditions, as well as risk mitigation for predator attacks.
 - using procedures to monitor and maintain the facilities and have a response plan prepared in advance to respond to a serious event of escapees.

⁶ Exempted species also relevant to use for this HELCOM BAT/BEP are listed in the Regulation (EC) No 708/2007 Annex IV.

- 1. EU "Regulation concerning the use of alien and locally absent species in aquaculture (Regulation (EC) No 708/2007)"
- 2. ICES Code of Practice (CoP) on the Introductions and Transfers of Marine Organisms outlines an approach to management and risk handling.
- 3. <u>EU regulation 1143/2014</u> on the prevention and management of the introduction and spread of invasive alien species, including full definitions on alien species (art3)
- 4. Article 8(h) of the Convention on Biological Diversity (CBD)
- 5. CBD Decision VI/23 on alien species that threaten ecosystems, habitats or species, the annex of which sets out Guiding Principles for the prevention, introduction, and mitigation of impacts of alien species.
- 6. Aquaculture Code of Practice: Containment of and Prevention of Escape of Fish on Fish Farms in relation to Marine Mammal Interactions, Scotland. 2021

10. Considerations on the implementation of animal welfare issues in aquaculture

Good animal welfare is fundamental to the idea of sustainability and is therefore a relevant aspect of sustainable aquaculture operations in the Baltic Sea. It is a prerequisite to avoid and minimize possible pollution from aquaculture operations like emission of hazardous substances since well-kept animals are healthier, which reduces the use of veterinary medicines. Within these considerations, animal welfare has to be considered to the same extent as all other sustainable development goals.

Besides these general recommendations, animal welfare is a complex topic, and there is still no single definition available that might guide respective actions. The numerous definitions of welfare all share the idea that a multidimensional approach is needed to fully address its complexity, e.g., good welfare can be assumed when basic health and functioning are safeguarded, when the animals are able to live a natural life and when they can also experience affective states. This implies that animal welfare is closely linked to other topics such as appropriate nutrition, husbandry practices and hygiene. The multidimensional nature of animal welfare has to be incorporated in welfare standards that are increasingly being demanded by policy and the public, not only for aquaculture but for all forms of livestock farming. Welfare standards should help farmers to adapt production routines and farm management. Welfare standards implemented in corresponding labelling should allow and guide the consumers to make a conscious purchase decision. It should also guide policy in order to identify needs for political action.

Due to the increasing diversity of aquatic animal species reared in aquaculture, animal welfare assessment, however, is not an easy task. In addition to necessary species-specific considerations, different developmental stages and, in turn, rearing systems pose specific requirements regarding the welfare of aquatic organisms. One potential solution is to develop robust species-specific operational welfare indicators (OWI)⁷, to be selected and evaluated for their validity, reliability, and practicality for each respective species, developmental stage, and cultivation system. Several such developments are on their way, and a lot has been achieved in recent years.

The collected information should be compiled and harmonized, and guidelines be derived and communicated with farmers and regional authorities. This may subsequently result in a continuous assessment and monitoring of welfare indicators that will then allow to evaluate the state of welfare, track its development over time, and compare different cultivation systems as well as sites. Farmers may also use this information to evaluate their performance in terms of the state of welfare on their farms. In addition, welfare scores may be integrated into evaluation schemes assessing the overall sustainability of production and thus allow for a comparison with other types of livestock farming. This may help to identify and promote the most sustainable animal production systems in terms of best technologies and practices.

- 1. EU Guidelines on sustainable aquaculture (section 2.2.2): <u>https://oceans-and-fisheries.ec.europa.eu/policy/aquaculture-policy_en</u>
- 2. Branson E.J. (ed) (2008): Fish Welfare. Blackwell Publishing Ltd, Oxford, xvi + 300 pp, ISBN:9780470697610
- 3. Huntingfort F. Kadri S. Jobling M. (eds) (2012): Aquaculture and Behaviour. Blackwell Publishing Ltd, Oxford, xvi + 358 pp, ISBN:9781444354614

⁷ OWI=operational welfare indicators are indicators for the welfare of cultivated animals that can be assessed on site.

11. Underwater Noise from Seal Scarers

No or minimal harm to marine life from man-made noise is one of the ecological objectives of the 2021 HELCOM Baltic Sea Action Plan (BSAP). Its action S61 '*Develop and implement guidelines for the design and use of acoustic deterrent devices to avoid detrimental impacts on the environment from underwater noise by 2024'* is related to aquaculture. The frequent, often preventive, use of acoustic deterrent devices (ADDs) in aquaculture emitting intense sound is aimed at reducing seal predation. Scientific evidence from various studies suggests that intense sound, such as that from ADDs, causes acoustic disturbance and hearing impairment in marine mammals such as harbour porpoises and displacement of high-frequency hearing specialists in fish (Dähne et al., 2017, Findlay et al., 2021, Ross et al., 1996, Götz and Janik, 2013, Brandt et al 2013). Thus, it is important to avoid or minimize acoustic disturbance and noise pollution from sustainable aquaculture operations.

It is essential to understand possible impacts and benefits of ADDs, such as frequency ranges, maximum source levels and duty cycles when assessing their impact. Furthermore, it is also essential to understand pros and cons of using ADDs in aquaculture in relation to avoidance of predation and fish mortality, increase of escapees and stress on farmed fish and unintended environmental effects, as mentioned above, as well as animal welfare for the farmed fish. These aspects could be considered by the competent authorities and aquaculture producers in relation to ADDs.

The future use of ADDs in aquaculture should consider the HELCOM guidance for the design and use of acoustic deterrent devices to avoid detrimental impacts on the environment from underwater noise, still to be developed under BSAP Action S61 by 2024.

- 1. Dähne, M., Tougaard, J., Carstensen, J., Rose, A., Nabe-Nielsen, J., 2017. Bubble curtains attenuate noise from offshore wind farm construction and reduce temporary habitat loss for harbour porpoises. Mar. Ecol. Prog. Ser. 580: 221-237
- Brandt, M., Höschle, C., Diederichs, A., Betke, K., Matuschek, R., Witte, S., Nehls, G. 2012. Farreaching effects of a seal scarer on harbour porpoises, Phocoena phocoena. Aquatic Conservation. 23 (2): 222-232
- 3. Findlay, C.R., Aleynik, D., Farcas, A., Merchant, N.D., Risch, D., Wilson, B., 2021. Auditory impairment from acoustic seal deterrents predicted for harbour porpoises in a marine protected area. J. Appl. Ecol. 58: 1631-1642
- 4. Götz, T., Janik, V.M., 2013. Acoustic deterrent devices to prevent pinniped depredation: efficiency, conservation concerns and possible solutions. Marine Ecology Progress Series 492: 285–302
- 5. Ross, Q.E., Dunning, D.J., Menezes, J.K., Kenna JR., M.J., Tiller, G., 1996. Reducing Impingement of Alewives with High-Frequency Sound at a Power Plant Intake on Lake Ontario. North American Journal of Fisheries Management 16: 548-559

12. BAT/BEP for staff training

Sufficient, qualified, and skilled staff is essential for the successful operation of aquaculture enterprises with respect to technical performance, environmental protection, avoidance of marine litter, animal welfare, and mitigation of underwater noise. Fit for purpose staff training is therefore a key element to ensure that Best Environmental Practices as proposed in this document are successfully implemented in aquaculture activities. Annual re-briefing of staff in compliance with relevant BAT/BEP, which can be organized internally or externally, should be carried out and be recorded. Minimum staffing requirements may be covered by the applicable national legislation of the Contracting Parties.

13. Reporting requirements

Actions taken by the Contracting Parties to implement Recommendation 37/3 should be reported for the first time two years after the approval of this document and thereafter every six years. Reporting serves the main purpose of following progress in implementation of the HELCOM Recommendation and contributes to providing data for assessing the impacts of aquaculture in the Baltic Sea region. The information gained from reporting can also support HELCOM in its role of acting as a regional platform for the regular exchange of information on the development of BAT/BEP descriptions for sustainable aquaculture in the Baltic Sea region, as well as delivering information for the update of the BAT/BEP if needed. The reporting format to be used can be found in Annex 2.

Further information in particular concerning nutrient loads from aquaculture operations should be reported according to HELCOM Guidelines for the annual and periodical compilation and reporting of waterborne pollution inputs to the Baltic Sea (PLC-water) (HELCOM 2019).

References

1. HELCOM Guidelines for the annual and periodical compilation and reporting of waterborne pollution inputs to the Baltic Sea (PLC-Water). HELCOM 2019.

Annex 1. Aquaculture systems in the Baltic Sea and their environmental impacts

Open cages

Open cage aquaculture is farming of fish by enclosing them in cages. The net cage is situated in natural waters. Marine cages consist of floating netted culture units. The net cages are moored to the seafloor or lakebed and feeding is done from platforms or boats. This production type is used in the Baltic Sea for production of rainbow trout in marine cages (e.g. Estonia, Finland, Denmark, Sweden) and in large freshwater lakes/water reservoirs (Finland, Sweden, Russia).

Open cages are feed based systems that have no physical barrier to prevent uneaten feed, faeces, veterinary medicinal products and cleaning, antifouling, and disinfecting agents from being emitted directly into the surrounding environment. Also, the risk of farmed fish escaping from the cages exists. Net cages can therefore, unless well-managed and following a permitting process, have an impact on the ambient ecosystem and applying effective BAT/BEP is necessary to minimise such impacts.

Semi-closed containment systems

Semi-closed containment systems (S-CCS) have been developed for the cultivation of Atlantic salmon in the marine environment, especially with focus on sea lice problems. The semi-closed nature of these systems may offer scope for the use of filtration or other methods of reducing nutrient discharges to the receiving environment. It may also help to prevent or minimise the usage of veterinary medicines whilst offering a barrier to parasites where needed. The technological readiness of these systems appears to be increasing. These systems may become available for use for producing species such and rainbow trout in the Baltic Sea, but this is yet to be demonstrated. Seasonal ice formation may threaten the structural integrity of these systems, and they should therefore either be capable of withstanding such events or be moved to safer locations during winter conditions.

Extractive aquaculture and integrated multi-trophic aquaculture

Integrated Multi-Trophic Aquaculture (IMTA) systems incorporate the cultivation of species of different trophic levels together based on the concept that one species' uneaten feed and wastes, nutrients, and by-products can be recaptured and converted into fertilizer, feed, and energy for other crops. Typically, fed species (e.g., finfish) are combined with extractive species (e.g., seaweed, mussels) so that the nutrient emissions resulting from feeding and subsequent metabolic processes can be re-utilised. The goal is generally twofold – to reduce nutrient losses and to increase the productivity of extractive species by a more efficient utilisation of resources within the aquatic environment. Integrated aquaculture with its nutrient recycling could contribute to the sustainability of aquaculture, having a lower ecological footprint than conventional aquaculture (Folke et al. 1998). Whilst the scientific basis for IMTA systems is reasonably well established and small-scale pilot studies have been largely successful, a widespread use by the aquaculture industry is still to be seen.

Nutrient extractive aquaculture describes the cultivation of aquaculture species with the primary purpose to remove nutrients. Since the Baltic Sea is highly eutrophic, nutrient extractive aquaculture can be employed as a nutrient management measure to remove nutrients after they have entered the sea. So far, this has mainly been practiced in enclosed coastal waters bodies or fjords (e.g., Szczecin Lagoon, Limfjorden, Horsens Fjord).

The most commonly considered extractive species are seaweeds and mussels. Mussels extract part of their diet from suspended particulate matter; however, discharge by finfish cultivation is still to be acknowledged as suitable source of food for mussels. Benthic loading from settling solid bound nutrients at finfish farms will decrease if the quantity removed by co-cultivated mussels is larger than the total nutrient content of mussel faecal and pseudofaecal deposition.

Extractive aquaculture is not without impacts since it generally constitutes an anthropogenic intervention and disturbance of natural ecosystems. Concerning mussel aquaculture, mussels excrete faeces and pseudofaeces that can accumulate as biodeposits on bottom sediments, with possible negative impacts on benthic communities such as smothering and oxygen depletion.

The European seaweed production is so far still at an early development stage, however, according to EU communication "Towards a Strong and Sustainable EU Algae Sector", strong algae industry centred on aquaculture production and innovative seaweed mariculture can be developed in Europe. Currently, the EU is a top global importer of seaweed products in terms of value, and the EU demand for algae and algae-based products is expected to increase in the coming years.

Pond aquaculture

The basic morphometric features of ponds in pond aquaculture are related to biological requirements of the cultured fish and of the animal organisms which constitute their natural food basis. Pond aquaculture farms are composed of a variety of different pond structures. There are growing fishponds, wintering ponds, used during the winter for first year (fry) or second year old fish and those used for wintering of the brood stock.

Proper cultivation of ponds (liming, fertilisation) in pond aquaculture allows for the production of bacteria, plants and animals (worms, insects, etc.) which live in the water and in the bottom of ponds. By consuming these living organisms, fish can satisfy their protein requirements. Utilising the living organisms as feed also enables that the fish only need to be fed the relatively cheap, energy-rich supplementary feeds to maintain their optimal growth. In addition, proper cultivation of carp ponds can contribute to utilisation of nutrients of and thus minimise eutrophication of discharged waters. When ponds are provided with fertilizers, the environment has to be considered, taking into account the possible filtration and existing nutrient content in ponds etc.

Flow-through ponds and tanks

Flow-through aquaculture is the most common land-based production method of trout and other salmonids. Elongated, rectangular ponds are a typical example of a flow-through system. Flow-through ponds are typically located in the vicinity of springs or at the upper reach of creeks and rivers providing cool and clean water rich in oxygen. Water discharges from flow-through systems are usually continuous. Water from a stream or river enters the system at its inlet and exits via an outlet located downstream of the same watercourse. Depending upon characteristics such as the size and shape of raceways, and the rate of water flow, the proportion of nutrient-containing solids remaining within flow-through systems may be significant. This reduces the need for mechanical filtration, and water is in certain cases discharged directly into the surrounding watercourse without prior treatment. Larger farms often have settlement ponds, constructed wetlands or technical devices for processing of effluent waters prior to discharging them into open waters. Compared to traditional, relatively simple raceway designs, the operation of some more modern flowthrough systems depends upon a greater use of technology. Typical examples of such can be found among salmon smolt and Danish trout production facilities, which produce fish in volumes far exceeding those of small basic flow-through designs. Larger production volumes produce greater quantities of nutrient containing solids, and so it is not uncommon for outlet water to be subject to mechanical filtration prior to being discharged. Filtration of outlet water may also be a feature of basic flow-through systems to maintain regulatory compliance.

Recirculating aquaculture systems

Water treatment prior to its reuse is one of the features of RAS. Different RAS systems with different degrees of water re-use exist. Typically, RAS has two primary water flows. A smaller volume consists of sludge originating from sedimentation systems, particle filtration and system backflush and has high percentage of phosphorus and organic matter. A larger volume of water has lower solids level but contains most of the nitrogen discharge. These two streams, "sludge" and "overflow" are typically processed separately to reduce RAS nutrient discharges. The degree of water re-use intensity defines the water treatment steps necessary for maintaining good water quality for fish growth and welfare. Water use intensity also plays an important

role in the nutrient capture efficiency, the more intense the water use, the higher are the concentrations of nutrients in the water and sludge streams, and higher reductions are possible than in larger water and sludge streams. However, a fraction of cultivation water is always discharged (e.g., 5-10% of total water volume), so that RAS systems cannot be considered as fully closed, thereby still causing local environmental impacts that necessitate effective and costly discharge control technologies.

Energy consumption is higher in RAS production compared to flow-through and cage farming operations. This is due to energy intense technologies, especially water pumping, temperature control of the water and building, and other technologies. Given the current climate crisis, the increased CO₂ emissions in RAS can be considered problematic. However, taking into account the constantly growing pollution of open waters and their decreasing resources, the lower interference of RAS in the natural environment (e.g., compared to cage farming in open waters), low water use per produced ton fish, and the recirculation of water through mechanical filtration and biological treatment provide more controlled conditions of fish rearing. Furthermore, provided that microbiota⁸ is controlled, this leads to prevention of infections of viruses and bacteria, and thus also minimizing the administration of possible antibiotics and other substances potentially harmful to the environment. Emphasis on research and implementation of most advanced energy-reducing technologies (e.g., renewable energy) is key for a climate friendly fish production in RAS.

References:

1. Balon, E. K. (2004). About the oldest domesticates among fishes. Journal of Fish Biology, 65(SUPPL. A), 1– 27. https://doi.org/10.1111/j.1095-8649.2004.00563.x

2. Folke, C., Kautsky, L., Berg, H., Jansson, A., Troell, M., 1998. The ecological footprint concept for sustainable seafood production: a review. Ecological Applications 8, 63-71.

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4. Woynarovich, A., G. Hoitsy, and T. Moth-Poulsen. 2011. Small-scale rainbow trout farming. FAO Fisheries and Aquaculture Technical Paper No. 561, Fisheries and Agriculture Organization of the United Nations, Rome, Italy, 81.

5. Woynárovich A., Moth-Poulsen T., Péteri A. 2010: 'Carp Polyculture in Central and Eastern Europe, the Caucasus and Central Asia'. A manual. FAO Fisheries and Aquaculture Technical Paper no 554;

6. Szczerbowski, J.A., Zdanowski, B. et al. 1993: 'Inland Fisheries in Poland', Wyd. IRS Inland Fisheries Institute in Poland. Pp 570.

⁸ "microbiota" refers to (potentially) pathogenic organisms, mostly bacteria and viruses, which need to be controlled e.g., by UV light or peracetic acid. In a RAS, the risk of incidental introduction of pathogens is reduced, but once they are in, they can spread easily due to the low water exchange and typically high density of cultivated organisms.

Annex 2. Reporting Form for HELCOM Recommendation 37/3 on Sustainable Aquaculture in the Baltic Sea region and BAT/BEP descriptions

Reporting form for HELCOM Recommendation 37/3 on Sustainable Aquaculture in the Baltic Sea region							
Note that it has been specified for which facilities (land-based or marine) the information is required.							
Where it is required for both, please distinguish land-based and marine facilities in your answer.							
Country: Year:							
	d production of mar	ine aqu	acultur	e operations			
Number and production (ir							
active marine finfish farms	per HELCOM sub-						
basin ⁹ :							
Number and net production							
active marine farms cultur							
not fed per HELCOM sub-b							
Number of marine facilities	s that have a						
permit:							
B. Species cultured	10						
Land-based facilities:		Marin	е				
		faciliti	es:				
C. Escapees from ma	arine facilities						
Approx. number and specie							
from marine facilities per r							
D. Nutrient discharg	es for marine faciliti	es					
Maximum allowable discha	arge		Maxii	mum allowable discharge of			
of nitrogen (tons/year) per			phosp	ohorus (tons/year) per			
HELCOM sub-basin ¹¹ :			HELC	OM sub-basin ⁹ :			
Alternatively, maximum			Alteri	natively, maximum allowable			
allowable use of nitrogen i	n		use o	f phosphorus in feed			
feed (tons/year) per HELCO	M		(tons,	/year) per HELCOM sub-			
sub-basin ⁹ :			basin	9:			
E. Waste manageme	ent practices for aqu	aculture	e facilit	ies (please distinguish in your a	answers		
between land-bas	sed and marine facili	ties)					
Mortality management pra	actices:						
Management of aquacultu	re processing						
wastes:							
Sludge management pract	ices:						

⁹ <u>Please use HELCOM level 3 for the definition of Baltic Sea Sub-basins, see:</u>

<u>https://maps.helcom.fi/website/mapservice/# (under monitoring – assessment units - HELCOM assessment units)</u>. Please provide a map if possible.

¹⁰ Please provide a full list of all species <u>cultured and include finfish as well as non-fed species</u>.

¹¹ Basin division as under footnote 7 applies. If confidentiality does not allow for a basin-specific reporting then nationally aggregated data can be reported instead.

F. Hazardous substances used in marine facilities									
Veterinary Medicines									
Establishment of Biosect	urity plan (yes/no)								
Active	Therapeutic Amount [t]								
pharmaceutical	group			221/-4		214.2	1		
ingredient (API)		202X	20)2X+1	20)2X+2			
		-	_		-				
Antifouling							1		
Biocide-free antifouling	strategies								
Please describe strategie									
Biocidal antifouling									
		ocidal prod	uct	Amou	unt [l]				
	ne biocidal active (na ubstance in the	ame)		202X		202X	+1	202X+2	
	roduct							-	
p'	louuci								
	_								
Disinfectants									
Disinfectant active	Product (name)	Amount [l]							
substance		Amount [i]							
Substance	2	202X	2022	X+1	202)	< +2			
G. Plastic waste in	n aquaculture facilitie	c (land ha	sod ar	ad mari					
Strategies to reduce plas		:5 (lallu-ba	seu ai		ne)				
	stie waste.								
H. Use of seal sca	rers								
Are seal scarers used (ye									
Is their operation under		ess (ves/no	o)?:						
I. Staff training	<u> </u>	()	,						
Is regular staff training a	s described in Chapte	er 12 carrie	d						
out (yes/no) and at what		-							

Glossary

ereceary	
Open cage aquaculture ¹	Farming of animals by enclosing them in cages which are situated in natural waters.
Semi-closed containment systems (S-CCS) ¹	Aquaculture systems that separate the animals from the sea environment by surrounding the farm with an impermeable bag.
Integrated Multi-Trophic	Multiple aquatic species from different trophic levels are farmed in an
Aquaculture System (IMTA) ¹	integrated way to improve efficiency, reduce waste, and provide ecosystem services, such as bioremediation. The IMTA cultivation allows one species' uneaten feed and wastes, nutrients, and by-products to be recaptured and converted into fertilizer, feed, and energy for other crops.
Pond aquaculture ¹	Inland aquaculture system which may periodically be emptied and refilled, mainly during and following harvest.
Flow-through tanks ¹	Systems in which water runs straight through the tank without reuse or
U U	recirculation and the water is treated by oxygenation and temperature regulation.
Recirculation Aquaculture	Aquaculture plants where a considerable part of water is re-used by
Systems (RAS) ¹	utilizing processes to remove harmful substances from the water before re-use.
Primary processing ¹	The first processing of aquaculture products such as slaughtering.
Secondary processing ¹	Subsequent processing such as filleting.
Feed conversion ratio (FCR) ¹	A measure of the amount of feed used to produce an amount of fish. For
	example, if 1.25 kg of feed is used to produce 1 kg of fish, the feed
	conversion ratio is 1.25: 1, or simple 1.25.
Biological food conversion ratio (bFCR) ¹	The quantity of feed consumed by a fish that is converted to fish mass.
Economic food conversion	Biological FCR plus the quantity of feed consumed by fish that is eventually
ratio (eFCR) ¹	lost through mortality, and the quantity of uneaten feed.
Maximum allowable inputs (MAI) of nutrients	Indicates the maximum level of inputs of water and airborne nitrogen and phosphorous to the Baltic Sea sub-basins to reach good environmental status of the Baltic Sea as defined by HELCOM (https://helcom.fi/baltic-sea-action-plan/nutrient-reduction-scheme/maximum-allowable-inputs/).
Nutrient input ceilings (NICs)	Maximum inputs via water and air to achieve good status with respect to
	eutrophication for Baltic Sea sub-basins for each country as defined by HELCOM (https://helcom.fi/baltic-sea-action-plan/nutrient-reduction-scheme/national-nutrient-input-ceilings/).
Sludge	Residual product of aquaculture, can contain nutrients, solid wastes (e.g., fish faeces and uneaten feed) and hazardous substances.
Fallowing periods ¹	Periods when production is paused.
Assimilative capacity	Ability of the environment to absorb pollutants without adverse effects to the environment and those using it.
Grading	Separating/sorting of cultured fish into groups based on size, by manual/mechanical graders.
Sustainable feed ²	Feed ingredients that are sourced in the way that is most respectful of ecosystems and biodiversity and which, at the same time, are appropriate for ensuring the health and welfare of the animals.
Biosecurity plan	Refers to measures aiming at preventing the introduction and/or spread of diseases and therefore reduces the use of veterinary medicinal products.
Immunostimulants	Work by stimulating the immunological response of fin fish species, therefore increasing their resistance against pathogen diseases (Dawood et al., 2017).
Prophylactic	A medicine or course of action used to prevent disease.

Antifouling	Treatment to prevent accumulation of micro-organisms, plants, algae and/or small animals on surfaces (e.g., nets) where they are not wanted
Endocrine disruptors (ED)	Chemicals that may interfere with the endocrine (hormonal) system of humans and wildlife, causing harmful effects to human health and/or the environment.
Biocide	Chemical substance or microorganism used to control harmful organisms.
CLP regulation	Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on the classification, labelling and packaging of substances and mixtures (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32008R1272).
SUP-directive	Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment (https://eur-lex.europa.eu/legal- content/EN/ALL/?uri=CELEX%3A32019L0904)
Non-indigenous species ³	 (a) a species or subspecies of an aquatic organism occurring outside its known natural range and the area of its natural dispersal potential; (b) polyploid organisms, and fertile artificially hybridized species irrespective of their natural range or dispersal potential.
Locally absent species ³	A species or subspecies of an aquatic organism which is locally absent from a zone within its natural range of distribution for biogeographical reasons.
Forage fish	Fish that are eaten by other fish and animals (e.g., herring and sprat).

¹UBA (2023): Developing BAT/BEP with respect to pollution by nutrients and hazardous substances for sustainable aquaculture operations in the Baltic Sea region. Dr. Steven Prescott, Kyra Hoevenaars, Lena Schenke, Severine B. Larroze, Zoe J. Fletcher, Tamás Bardócz, Dr. Clara Piquer, Dr. Marcelo R. Vera, Dr. Alexis J. Conides; AquaBioTech Group, Targa Gap, Mosta, Malta G.C. On behalf of the German Environment Agency. Project number 118785. 114 pages

² EU Guidelines on sustainable aquaculture (section 2.2.2): https://oceans-and-fisheries.ec.europa.eu/policy/aquaculture-policy_en

³ Council Regulation (EC) No 708/2007 of 11 June 2007 concerning use of alien and locally absent species in aquaculture.

List of commonly used abbreviations

BAT	Best Available Technology
BEP	Best Environmental Practice
PBT	Persistent, bioaccumulative and toxic
vPvB	Very persistent and very bioaccumulative
SVHC	Substances of very high concern