ENVIRONMENTAL MONITORING PROGRAM FRAMEWORK FOR MARINE AQUACULTURE IN NOVA SCOTIA

NOVA SCOTIA

Fisheries and Aquaculture

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Environmental Monitoring Program Framework for Marine Aquaculture in Nova Scotia

1. INTRODUCTION

The Nova Scotia Aquaculture Environmental Monitoring Program (EMP) began in the fall of 2002 when the Aquaculture Association of Nova Scotia (AANS) produced a draft plan recommending that the Province implement and regulate an EMP for the marine aquaculture industry. This draft plan originated from the document *Design of the Environmental Monitoring Program for the Marine Aquaculture Industry in Nova Scotia* (Smith et al., 2002). The Aquaculture Division of the Nova Scotia Department of Fisheries & Aquaculture (NSDFA) accepted the lead role and began implementing the EMP.

The EMP examines the relationship between an aquaculture operation and the surrounding benthic marine environment. Environmental monitoring takes place at stations located directly within the lease boundaries and at a reference station(s) that is located outside of the lease boundaries.

The EMP applies to all active and inactive, marine finfish and shellfish aquaculture leases in Nova Scotia. As of March 2021, there were a total of 206 licensed marine aquaculture sites in Nova Scotia (164 shellfish, 35 finfish, and 7 shellfish/marine plant sites). Species grown at marine aquaculture leases in Nova Scotia include: salmon, trout, mussels, scallops, clams, quahogs and oysters.

The regulatory provisions for the EMP are referenced in the Aquaculture Management Regulations (S.10-11 and S.30-32) created pursuant to the Fisheries and Coastal Resources Act (S.64). Each operator is responsible to include all information and procedures related to the EMP in their site-specific Farm Management Plan. In addition, a Memorandum of Understanding (MOU) has been signed by both the NSDFA and Fisheries and Oceans Canada (DFO) stating responsibilities of each party:

"The Parties will co-operate in the development of an industry wide environmental effects monitoring program. Nova Scotia will be responsible for the implementation of the environmental effects monitoring program and the implementation of a follow-up program, where applicable, and will report to Canada in a manner that is mutually agreeable to the Parties."

The EMP uses a risk-based approach to monitoring that recognizes that increased risk requires increased monitoring. This risk-based approach is based on almost two decades of empirical data that has been collected across the spectrum of Nova Scotia aquaculture activities and environmental conditions. This approach can be consistently applied to the diverse nature of the aquaculture industry in the province. The dataset includes a variety of environmental indicators and variables to define environmental performance. Over time these site-specific datasets can be used to identify how each aquaculture lease interacts with the surrounding marine benthic environment.

All marine aquaculture leases that currently have production are assessed as part of the EMP. Active marine finfish sites are required to conduct monitoring at least once annually. Additional monitoring, remediation and mitigative actions may be required based on results from annual

monitoring. Active shellfish sites may be required to conduct monitoring if deemed necessary by NSDFA or DFO. It should be recognized that shellfish culture is different with respect to environmental interactions, and that the monitoring and management practices reflect this difference.

Environmental monitoring is a critical part of the management of a marine resource industry. NSDFA believes that the growing body of data that has been and will continue to be collected, helps to ensure that the aquaculture industry in Nova Scotia remains environmentally sustainable.

This document is designed as a companion paper to the *Standard Operating Procedures for the Environmental Monitoring of Marine Aquaculture in Nova Scotia* (NS EMP SOP; PNS 2021B). These documents are intended to be used as a framework and protocol for environmental monitoring of the Nova Scotia aquaculture industry. These documents will be reviewed and adjusted as needed.

The objective of this document is to detail key components of the NS EMP. These are:

- **Environmental Management Framework –** this section describes the rationale for the regulatory framework and determining appropriate levels of monitoring;
- **Site Management Responses** – this section describes site management responses based on the environmental quality classification reported from a sample location with reference to industry Best Management Practices (BMP);
- **Committees for Regulation and Development of Environmental Management Outcomes** – this section describes the role and responsibilities of the committee to make recommendations on the conduct of the EMP;
- **Annual Schedules** – this section describes the timing deadlines for monitoring and mitigation; and
- **Auditing and Reporting** – this section describes the types of auditing that will be performed by NSDFA as well as the reporting requirements for Industry self-monitoring.

2. ENVIRONMENTAL MANAGEMENT FRAMEWORK

The NS EMP lays out a series of principles and criteria to guide the management process and to determine the level of monitoring required for each aquaculture lease. Depending on the monitoring results, the EMP also provides guidance on the level of mitigation required for an aquaculture lease.

2.1. Monitoring Principles

The information obtained from the monitoring program is valuable both to government regulators and the aquaculture industry. Monitoring is carried out to:

- Ensure compliance with conditions of a site approval;
- Ensure environmental quality objectives (EQOs) and other standards are met;
- Assess the effects of an operation on the environment;
- Verify and validate mathematical models (if any);
- Determine mitigative action to be taken (if any); and
- Audit the results of self-monitoring.

One of the primary concerns regarding a marine aquaculture operation is the potential for negative impact on the surrounding marine benthic environment through organic loading. Significant organic deposition can result in increased Biological Oxygen Demand (BOD) in benthic sediments. If BOD is greater than the incoming supply of oxygen, hypoxic or anoxic sediment conditions will result, potentially impacting localized fish habitat and decreasing the abundance and diversity of macrofauna populations.

The EMP aims to monitor such impacts in benthic communities through both geochemical analysis of sediments and the assessment of visual indicators of hypoxic conditions. These assessments are used to classify the environmental performance of an aquaculture lease based on established relationships between the collected parameters and benthic community health. In instances where site classification indicates compromised benthic conditions as a result of organic loading, the EMP dictates increasing levels of monitoring to improve understanding of the scope and severity of the impacts as well as mandatory management responses to be undertaken by the facility operator.

The primary EQO for the marine environment where an aquaculture operation occurs is to maintain oxic sediment conditions. If oxic sediment conditions cannot be maintained within a lease, operators must comply with the regulatory process that identifies steps required to improve onsite environmental conditions.

2.2. Station and Site Classifications

In July of 2015, the Aquaculture Activities Regulations (AARs) were introduced by the Department of Fisheries and Oceans Canada (DFO), resulting in the creation of federal monitoring requirements which aquaculture site operators must comply with in addition to the provincial program. The AAR's inclusion of assessment requirements for stations where sediments can not be collected has since led to the incorporation of similar considerations within the Nova Scotia Environmental Monitoring Program for assessing and classifying stations and leases (AAR 2021). While previous iterations of the EMP relied solely on measurements of sediment sulfide ion concentration to determine environmental impacts, the inclusion of hard bottom monitoring methodologies has required the consideration of additional benthic health indicators and classification metrics for the assessment of the environmental performance of aquaculture operations.

2.2.1. Determination of Monitoring Station Type

All monitoring events conducted under the Environmental Monitoring Program consist of the assessment of a series of individual monitoring stations. The means by which these stations are assessed and how the results are used in the classification of the environmental performance of an aquaculture lease as a whole is dependant on the representative bottom types present. Within the context of the EMP, monitoring stations can be considered hard bottom or soft bottom stations. A monitoring location is considered to be a soft bottom station only when a sufficient number of sediment samples can be collected which satisfy the methodology and quality criteria presented in Section 5 of the NS EMP SOP (PNS 2021B). Where the composition or consolidation of the benthic substrate is such that sufficient, acceptable samples can not be collected, a monitoring location will be considered a hard bottom station for the purposes of that monitoring event.

2.2.2. Environmental Indicators and Definitions

The NS EMP focuses on benthic marine habitat directly underneath the aquaculture site. The objectives of the environmental parameters assessed for soft and hard bottom stations are to:

- Maximize habitat information by providing scientific confidence in the parameters and methods of monitoring and analysis used to describe changes to the benthic community structure;
- Provide long-term record of habitat quality with variables that are sensitive to the potential organic enrichment effects of aquaculture;
- Provide repeatability and consistency in monitoring and analysis;
- Provide clear specification of spatial and temporal bounds; and
- Optimize logistics and field efforts while ensuring cost effectiveness.

Several additional, well-established, environmental indicators allow for the classification of sediment conditions into oxic, hypoxic and anoxic categories based on the following Environmental Quality Definitions (EQD). These indicators may be used, in addition to environmental performance classification metrics (Section 2.2.3) in determining specific site management response requirements resulting from the monitoring and classification of aquaculture leases.

Table 1. Environmental Quality Definitions

	Sediment Classification		
Measurement	**Oxic**	**Hypoxic**	**Anoxic**
Sediment colour	Tan to depth > 0.5 cm	Tan to < 0.5 cm with some black sediments at surface	Surface sediments black
Microbial presence	No *Beggiatoa*-like bacteria present	Patchy *Beggiatoa*-like bacteria	Widespread *Beggiatoa*-like bacterial mats
Macrofaunal Assemblage	Wide array of infauna and epifauna	Mixed group of mostly small infauna	Small infauna only
Sulfide, µM	**≤ 749 (A) 750 to 1499 (B)**	**1500 to 2999 (A) 3000 to 5999 (B)**	**≥ 6000**
Redox (Eh), mV_{NHE}	>100 (A) 100 to -50 (B)	-50 to -100 (A) -100 to -150 (B)	< -150
Organic matter, %	<= reference*	1.5 to 2X ref.	> 2X reference
Porosity, %	<= reference*	1 to 10X ref.	> 10X reference

Modified from the *Design of the Environmental Monitoring Program for the Marine Aquaculture Industry in Nova Scotia* (Smith et al 2002) and *Towards a Classification of Organic Enrichment in Marine Aquaculture* (Hargrave et al. 2008a)

2.2.2.1. Soft Bottom Environmental Indicators

The primary environmental indicator used to assess the benthic health at a soft bottom monitoring station is the mean concentration of free sulfide in the sediment. The use of mean sediment sulfide to classify the environmental quality of a soft bottom aquaculture station or lease is based on recommendations made by Wildish et al. (1999) in the paper, *A recommended method for monitoring sediments to detect organic enrichment from mariculture in the Bay of Fundy*. Sediment is generally considered to be hypoxic when sulfide levels reach 1500 micromoles per litre (µM).

Additional environmental indicators are assessed at soft bottom stations as a means of validating mean sediment sulfide results. These include oxidation-reduction potential (redox), porosity and organic matter prevalence in sediment. These indicators are incorporated into the calculation of a Benthic Enrichment Index (BEI), which provides a multi-variate measure of sediment organic enrichment. The index is correlated with total 'free' sulfides and biological indicators such as macrofauna biodiversity indices that can be altered by increased organic matter sedimentation, and the formation of hypoxic or anoxic conditions in sediment. It serves as an internal check by applying more than one method for quality control in monitoring programs using geochemical methods to measure benthic organic enrichment (Hargrave 1994, Shaw 1998, Holmer et al. 2005, Hargrave et al. 2008a, b). The index can, therefore, be used to verify the degree of benthic organic enrichment in marine sediment based on measures of sulfide (Hargrave, 2009).

Comparison of the relative sensitivity of variables for detecting sediment organic enrichment due to aquaculture, has shown that porosity and organic matter are not as good indicators of differences between farm and reference sites as redox. However, when combined with measures of redox to calculate the BEI, detection of differences between farm and reference site sediments using BEI, approaches levels obtained using sulfide (Hargrave et al., 1997).

Measurements of porosity and organic matter therefore serve more than one purpose. Primarily, these parameters allow inference of sediment texture to ensure that the depositional-erosional characteristics at farm and reference sites are comparable. In addition, they provide an internal check on data quality. Sediments with high porosity typically have higher levels of organic content. Over time, as data is collected from the same location, a database can be developed to identify temporal trends in organic matter to be detected independent of the effect of grain size inferred from porosity measurements. Finally, porosity must be known if the absolute mass of organic matter in surface sediments is to be calculated on a dry weight basis (Hargrave 2009). This is required not only for comparisons of organic matter in sediments from farm and reference locations, but to ensure that organic content inventories are being compared on the same basis between locations where porosity differs (Hargrave 2009).

Sulfate reduction and the production of sulfide are closely related to redox potential. While the relationship weakens somewhat for oxic sediments, redox acts as a quality control measure for sulfide measurements and vice versa (Grant 2010).

Detailed instruction for collecting and analyzing sediment and video for the assessment of soft bottom environmental indicators can be found within the NS EMP SOP (PNS 2021B).

2.2.2.2. Hard Bottom Environmental Indicators

The inability to collect sufficient acceptable sediment samples characterizes a monitoring station as hard bottom. For hard bottom stations, the primary environmental indicators used to assess benthic health result from visual observation of the seafloor at and nearby the monitoring station. The three (3) hard-bottom environmental indicators include: the abundance of *Beggiatoa*-like bacterial species, opportunistic polychaete complexes, and barrenness. The decision to use these indicators to asses the benthic health of hard bottom stations is based on recommendations made by DFO.

Methodology for assessing these indicators is explained by the Aquaculture Activity Regulations (AAR 2021) and supporting documents, found on DFO's website (Aquaculture Activities Regulations (dfo-mpo.gc.ca)) and in the NS EMP SOP (PNS 2021B) document, found on NSDFA's website (Aquaculture Management - Government of Nova Scotia, Canada).

2.2.3. Environmental Performance Classification of Sites

The metrics by which an aquaculture site's environmental performance is classified will depend on the proportion of monitoring stations which are determined to be soft and hard bottom during a given monitoring event. The Environmental Performance Classification of an aquaculture lease resulting from an annual Level I monitoring event will determine the required site management response, if any (Section 3). If an analytical or independent audit is conducted on a monitoring event, the results indicating a higher level of impact will be used to determine site management responses.

2.2.3.1. Predominantly Soft Bottom Sites

At sites where 75% or more of non-reference monitoring stations are determined to be soft bottom, the site's environmental performance classification will be determined using the mean sulfide ion concentration of sediment samples collected from these stations (Table 2). Monitoring locations which are determined to be soft bottom stations are subject to monitoring as described in the NS EMP SOP (PNS 2021B).

Table 2. Environmental performance classification levels and associated mean sediment sulfide concentrations for predominantly soft bottom sites

Site Classification	Sediment Sulfide Concentrations
Oxic A	≤ 749 µM
Oxic B	750 - 1499 µM
Hypoxic A	1500 - 2999 µM
Hypoxic B	3000 - 5999 µM
Anoxic	≥ 6000 µM

2.2.3.2. Predominantly Hard Bottom Sites

At sites where less than 25% of non-reference monitoring stations are determined to be soft bottom, the site's environmental performance classification will be determined using the proportion of stations which pass or fail visual assessment of benthic impacts. Monitoring locations which are determined to be hard bottom stations are subject to spatially expanded visual assessments consisting of multiple video collection locations, as described in the EMP SOP Section 4.2.2. If during these assessments, evidence of hard bottom indicators (Section 2.2.2.2) are observed at 70% or more of the video collection locations along a video transect, the monitoring station will be considered as having failed to meet the Environmental Quality Objectives of the EMP (PNS 2021B). If the number of stations which pass this visual assessment is greater than the number of stations which fail, the site will be classified as having passed. If the number of stations which fail is greater than or equal to the number of stations which pass this visual inspection, the site will be classified as having failed.

2.2.3.3. Mixed Bottom Sites

At sites where the number of stations determined to be soft bottom is between 25% and 74%, environmental performance classification will be determined using a combination of average sulfide ion concentrations from soft bottom stations and visual assessment results from hard bottom stations. Monitoring locations which have been determined to be hard bottom stations will be assessed as having passed or failed visual assessment, as described in Section 2.2.3.2. Soft bottom stations will be considered as having passed or failed based on the mean sulfide ion concentration of sediments collected from that monitoring location. Where mean sulfide concentrations are found to be $\geq$ 3,000 µM, the station will be considered as having failed. If the number of stations which pass is greater than the number of stations which fail, the site will be classified as having passed. If the number of stations which fail is greater than or equal to the number of stations which pass, the site will be classified as having failed.

2.3. Levels of Monitoring

A risk-based approach is required to address the variety of potential impacts on the marine benthic environment. The risk-based approach is based on the interaction of site conditions, culture methods and culture intensities that vary greatly among finfish and shellfish marine aquaculture operations in Nova Scotia. Sites are subject to baseline environmental monitoring. For more information on baseline requirements, please refer to Section 2 of the NS EMP SOP (PNS 2021B).

Up to three levels of monitoring events may be required in the annual assessment of a given aquaculture lease. Detailed methodology for conducting the required monitoring associated with each of these events is presented in the NS EMP SOP (PNS 2021B).

Level I –Level I monitoring is required annually on all active finfish sites. The site is classified on the results from the Level I monitoring unless further monitoring is required. Level I monitoring procedures are described in the NS EMP SOP (PNS 2021B).

Level II – Additional monitoring is required when the results of annual Level I monitoring classify a lease as Hypoxic B, Anoxic, having failed based on the mixed or hard bottom classification, , or as determined to be required through an audit. (Section 2.2.3). The additional information gathered during a Level II monitoring event is used to better define the outer limits of the affected area and

more effectively define the zone of influence. Level II monitoring procedures are described in the NS EMP SOP (PNS 2021B).

Level III – Monitoring is required when a site consistently fails to meet oxic conditions, when the results of annual Level I monitoring classify a lease as Anoxic or otherwise severely impacted, or at the discretion of NSDFA. This monitoring is used to capture seasonal variation on a lease and is used to closely monitor affected areas within the lease boundaries through increased temporal monitoring intensity. Additional requirements may be imposed at the discretion of NSDFA in order to better assess the environmental impacts and ongoing sustainability of an aquaculture operation. These may include, but are not limited to:

- The addition of more monitoring stations;
- The addition of seasonal monitoring events;
- Sediment profiling;
- Collection of oceanographic data, such as current profiles;
- Development of oceanographic models (e.g. flushing, carrying capacity, depositional); and/or
- Collection of additional water quality parameters.

Details and specific conditions of all follow-up monitoring are to be determined by NSDFA and DFO in discussion with the operator.

3. SITE MANAGEMENT RESPONSES

In order to meet the EQO of oxic sediment conditions, it is important to define a suite of measures that could be implemented to achieve the goal. These measures include BMP that are determined by industry and are deemed to be effective in mitigating potential environmental effects. If, after monitoring, there is evidence of organic enrichment on the site, then enhanced BMP's are to be implemented on the lease.

Potential site mitigation responses, as outlined in Appendix B of this document, will be based on results of annual Level I monitoring events, or results from an audit. Other parameters and information, such as redox, porosity, organic matter and video/visual observations will continue to be included as part of the weight-of-evidence approach for the overall site assessment and classification. These other parameters will aid in determining cause-effect relationships and appropriate management responses.

The following are management responses based on site classification of marine finfish aquaculture sites in Nova Scotia. Responses within the shellfish sector will be similar but more prescribed to the differences between shellfish and finfish growing operations (infrastructure, growing environments, etc.).

3.1. Oxic Site Responses

Sites classified as Oxic A or Oxic B are considered to have low environmental effects on the marine sediments. The operator will continue to follow the site's operational BMP's and will continue to complete annual Level I monitoring. If a site remains 100% oxic for two production cycles, and there is no significant stocking increase, they may apply to conduct EMP monitoring every 2 years instead of annually.

3.2. Hypoxic A Site Responses

Sites classified as Hypoxic A, or sites indicating audit results with a site sulfide mean between 1500-2999 µM, may be causing adverse environmental effects on marine sediments. In addition to following the sites BMP's for the lease, the operator will submit an updated mitigation plan to NSDFA for approval and must identify which predetermined risk control plans from their Farm Management Plan (FMP) are appropriate to address the sub-optimal environmental performance. The updated mitigation plan must be implemented in a timeframe determined by the Minister. The operator will be required to conduct Level I monitoring for the next monitoring season.

3.3. Hypoxic B Site Responses

Sites classified as Hypoxic B, or sites indicating audit results with a site sulfide mean between 3000-5999 µM, are likely causing adverse environmental effects on the marine sediments. Level II monitoring will be required at sites receiving this classification or as required due to audit results. In addition to following operational BMP's, the operator must submit an updated mitigation plan to NSDFA for approval and must identify which predetermined risk control plans from their FMP are appropriate to address the lease's poor environmental performance. The updated mitigation plan must be implemented in a timeframe determined by the Minister. The operator must also provide a strong rationale for maintaining or increasing production levels.

3.4. Anoxic Site Responses

Sites classified as Anoxic, or sites indicating audit results with a site sulfide mean ≥ 6000 μM, are considered to be causing adverse environmental effects on the surrounding marine sediments. Large portions of the site are likely affected due to the excessive accumulation of organic material. The operator must conduct both Level II and Level III monitoring on the site. The operator will work closely with regulators to resolve the situation. In addition to following the sites BMP's for the lease, the operator will submit an updated mitigation plan to NSDFA for approval and must identify which predetermined risk control plans from their Farm Management Plan (FMP) are appropriate to address the sub-optimal environmental performance. The updated mitigation plan must be implemented in a timeframe determined by the Minister.

3.5. Mitigation plans

When poor environmental performance (Hypoxic A, B, Anoxic, or Fail) has been determined through a Level I monitoring event (or an audit), the aquaculture operator must implement appropriate enhanced mitigation strategies. All enhanced mitigation measures to be implemented on an aquaculture lease must be submitted to NSDFA within **14 days** of receiving a **Hypoxic A site classification, within 14 days of a Level II monitoring event for Hypoxic B or Anoxic site classification, if the site is classified with a "fail" under the mixed and hard bottom protocol, or as required by NSDFA due to audit results**. The mitigation plan must specify the timelines in which the mitigation measures will be implemented and explain how the measures will reduce any environmental impacts caused by the operation , in addition to how each measure will be monitored to prevent recurrence. Additionally, the known production history of the site along with historical EMP performance and site characteristics will be important in determining mitigation and must be incorporated into an operator's updated mitigation plan.

Appendix A highlights the standard BMPs that all marine aquaculture operators are expected to implement as part of their daily operations. In addition to these BMPs, aquaculture operators are also required to determine enhanced mitigation strategies that can be implemented on a lease when poor environmental performance has been identified. Examples of enhanced mitigation measures that can be implemented by the operator when poor environmental performance has been identified are detailed in Appendix B. If the operator identifies that the recommended enhanced mitigation measures listed below are unsuitable for addressing the cause of the environmental impact(s), alternative mitigation strategies may be submitted. These alternate mitigation strategies must be approved by NSDFA prior to implementation.

4. COMMITTEES FOR REGULATION AND DEVELOPMENT OF ENVIRONMENTAL MANAGEMENT OUTCOMES

On an ongoing basis NSDFA consults with the Nova Scotia Aquaculture Environmental Coordinating Committee (NSAECC) which is co-chaired by NSDFA and DFO through the Canada-Nova Scotia MOU.

The NSAECC will provide a mechanism for both industry and regulators to provide input into the NS EMP processes. Any program revisions will be vetted through this committee. It has representatives from all aquaculture related regulatory agencies such as NSDFA, DFO, and representatives of the finfish and shellfish industry through the AANS. This body has no regulatory authority to make site specific decisions but is a means of exchanging ideas and making recommendations on the conduct of the EMP.

Under the MOU, NSDFA also takes the lead role in the management of the NS EMP through a Nova Scotia Aquaculture Environmental Site Management Committee (NSAESMC) which is co-chaired by NSDFA and DFO.

The NSAESMC provides a review on site-specific results of the NS EMP. This committee interprets the results of the NS EMP monitoring events and provides site-specific recommendations for any remedial action required. This approach provides a method of integrating the regulatory requirements of both agencies with respect to environmental management.

In summary:

- NSDFA and DFO co-chair the NSAECC;
- NSAECC has representation from NSDFA, Nova Scotia Environment and Climate Change (NSECC), DFO, AANS and other provincial and federal government agencies, as needed;
- NSAECC will be the advisory body and forum for information exchange with Industry on EMP matters;
- NSAESMC will be co-chaired by NSDFA and DFO. The committee will review EMP data and make remediation/mitigation recommendations based on EQOs and a risk-based approach; and
- NSDFA will perform the lead role on EMP management and will perform the audit function of the EMP, however regulators on the NSAESMC can make any determinations and actions on their own based on their respective legislation and regulations.

5. ANNUAL SCHEDULES

The optimal time for conducting environmental monitoring on a lease is when feeding and waste production (i.e., organic deposition) are at a peak for both marine finfish and shellfish operations. It is also important to complete monitoring when seasonal storm potential is limited.

Annual Level I monitoring of Nova Scotia marine aquaculture sites will be conducted from July 1st to October 31st. Level II monitoring will also be conducted between July 1st to October 31st. Dependent on when Level I monitoring occurs, Level II monitoring can also take place during the month of November. Level III monitoring will occur between March 1st and May 31st when the weather permits and prior to restocking a site with fish. Site operators are expected to comply with the schedules in Table 3 for the submission of data, materials, and, if necessary, updated mitigation plans. Only complete, final copies of reports, results, coordinates, log sheets and video are to be submitted. An electronic copy of the monitoring event and corresponding video files can be sent to Aquaculture Operations via the secure file transfer system upon request. Requests can be made by email to EMPSupervisor@novascotia.ca.

OR

A physical copy of the monitoring event and video files can be sent to the attention of Aquaculture Operations at the following mailing address:

Aquaculture Operations
Nova Scotia Department of Fisheries and Aquaculture, Aquaculture Division
1575 Lake Road
Shelburne, Nova Scotia
B0T 1W0

Incomplete reports and partial submissions are considered late. Any delays to these timelines require approval by the EMP Supervisor via email or telephone (902-875-7436).

The deadlines for each type of monitoring and mitigation response are as follows:

Table 3. Monitoring Deadlines for the Operator and NSDFA

Requirement	**Deadline for Industry**	**Deadline for NSDFA**
Annual Level I EMP Monitoring	Must be completed between **July 1st to October 31st**	
All submissions for Level I monitoring event	Must be submitted within **14 days** of the completion of Level I monitoring event.	
Level I Follow-up (Site Classification and QA/QC Audit Results)		Letter provided within **28 days** of Level I monitoring
Updated Mitigation Plan	Hypoxic A classification or as required due to audit results: updated mitigation plan must be submitted **14 days** after site classification notification.	Response provided to Industry within **14 days** of receipt of updated mitigation plan
Level II monitoring (Hypoxic B, Anoxic site classification, or as required due to audit results)	Must be completed within **35 days** of the Level I monitoring event.	
Updated Mitigation Plan and all submissions for Level II monitoring event	Must be submitted within **14** days of the completion of the Level II monitoring event.	
Level II Monitoring Follow-up (final site classification, mitigation plan status)		Letter provided within **28 days** of Level II monitoring
Level III EMP Monitoring	Must be completed between **March 1st and May 31st** of the following year and prior to stocking the site.	
All submissions for Level III monitoring event	Must be submitted within **14** days of the completion of the Level III monitoring event.	
Level III Follow-up (QA/QC Audit Results)		Letter provided within **28 days** of Level III monitoring

6. AUDITING AND REPORTING

Auditing will be conducted by NSDFA on an annual basis. All monitoring events (I, II and III) are eligible to be assessed via a NSDFA audit. The purpose of an audit is to ensure that the information submitted to NSDFA is accurate, consistent, and reliable. Access to accurate, consistent and reliable data ensures that government agencies and operators make sound management decisions. Audits are also used to ensure that the proper monitoring methodology is being followed. Detailed information regarding audit types and determination can be found within the Environmental Monitoring Program Audit Policy for Marine Aquaculture in Nova Scotia (PNS 2021A).

The principles of transparency and collaboration are tenets of responsible environmental management and described in the original 2002 EMP document (Smith et al. 2002); therefore, one goal of the NS EMP is to release information regarding the monitoring results to the public. NS EMP monitoring results can be accessed through the province's open data portal: https://data.novascotia.ca/.

APPENDIX A: Associated Best Management Practices for Marine Finfish Aquaculture - provided by Aquaculture Association of Nova Scotia (AANS)

These Best Management Practices are extracted from the New Brunswick Environmental Management Program for the Marine Finfish Cage Aquaculture Industry in New Brunswick (July 2006) as requested by industry representatives within the AANS.

The following Operational Best Management Practices are designed to minimize the organic and inorganic loading from marine finfish cage aquaculture sites and are a requirement of all marine finfish cage aquaculture operators.

Waste Management

- Cage site operators are required to develop and comply with site-specific waste management plans as required by provincial and federal regulators. The aim of the plan is to ensure proper disposal of all waste materials generated at the facility. Categories of waste include, but are not limited to operational debris, hazardous waste, human waste, bio-fouling, fish mortalities, fish feed, waste products from harvesting, etc.

Record Keeping and Reporting

- Marine finfish cage aquaculture site operators are required to maintain production records and report information as required by provincial and federal regulators; and
- Environmental monitoring data will be reported to NSDFA within timelines set out above in *Section 5: Annual Schedules.*

Equipment Cleaning (nets, cages, mooring, and other equipment)

- It is recommended that no net washing be conducted on-site, and that farmers monitor nets for biofouling organisms during routine mortality dives;
- In some circumstances, maintenance washing of lightly fouled nets still attached to cage structures is allowed on-site. However once nets are removed, they must be brought to shore for cleaning;
- Washing of lightly fouled equipment or nets with washing systems at the site will be conducted only under conditions that maximize dispersal of the dislodged materials away from the site and neighboring sites (e.g. strongest currents);
- Nets will be replaced at least at the beginning of each production cycle, and more often as required;
- No nets or other equipment shall be dropped to the bottom for the purpose of storage or cleaning. In the event of emergency circumstances such as worker safety or fish survival, any nets or equipment dropped to the bottom must be within lease boundaries and must be reported to NSDFA and DFO immediately; and
- Sites classified as Hypoxic B or Anoxic will not conduct any on-site net cleaning.

Equipment Disinfection (nets, cages, mooring, and other equipment)

- Steam is the only disinfectant to be used on-site to clean cages and equipment;
- The cages will be cleaned on the aquaculture site prior to transport to the off-site location where the disinfection will take place;
- Only the following disinfecting agents will be used to clean cages at a location other than on the aquaculture site: steam, chlorine-based solutions, iodophor-based solutions, and hydrogen peroxide-based solutions;
- Environment Canada (EC) has suggested maximum discharge concentrations for each of the indicated disinfectants so that runoff from the disinfection process should not be deleterious to fish. The release of disinfectant solutions to waters frequented by fish could be considered a violation of Section 36(3) of the federal *Fisheries Act* at concentrations above the following maximum values:
    - Chlorine = 0.02 ppm
    - Iodine = 0.1 ppm
    - Hydrogen peroxide = 0.5 ppm
- During disinfection, the disinfectants will be stored such that any spill is contained and not released into the environment. All reasonable precaution will be taken to avoid releases due to spills;
- Disinfection of cages will only take place during sunny days, especially with chlorine-based solutions. Bright sunshine will aid in decreasing the concentration of chlorine and speed up the evaporation of other disinfectant solutions;
- Care will be taken to ensure that disinfectant is not applied in excess. Direct discharge of disinfectants other than steam to waters of the province, including marine waters, is a violation of Section 36(3) of the federal *Fisheries Act*
- Disinfectant solutions will be directed only at cage structures, with care taken to avoid over-spraying onto the beach;
- Ample drying time will be allotted to ensure that all disinfectant has completely dried prior to inundation with the next high tide;
- The disinfection of the cages will be spread out over a number of days to reduce the potential for impacts from the disinfectant residues;
- Disinfectant storage will occur in an area not in danger of being inundated by tidal waters or any other water source; and
- To whatever extent possible, disinfection events will be coordinated with other growers within the same bay/harbour to spread it out over time and space.

Feed Handling and Storage

- Site staff and feed delivery personnel will take all reasonable precautions to reduce spills during delivery of feed to the site;
- Should a spill of feed occur, immediate cleanup is required to minimize the loss of feed into the ocean;
- Accurate records will be maintained detailing the amount of feed delivered to the site, stored at the site, fed to the fish, spilled and/or returned unused to the manufacturer. These records will provide a mass balance of feed use at the site;
- The amount of feed on site at any one time will be limited to an amount that can be safely and properly stored at the site;

- Feed will be stored, as much as practically possible, at the site in covered areas including hoppers, bins, or buildings so that spills and spoilage are minimized;
- Bags or open containers of feed will not be left exposed or uncovered at the site; and
- Any feed that is unusable will be removed from the site as new feed is delivered and disposed of at an approved site.

Feeding Practices

- Amounts of feed given to stock will be based on biomass contained in the pen and environmental conditions present;
- Feeding will be reduced or stopped if conditions such as low temperature, low dissolved oxygen, high tide currents, or heavy weather suggest that utilization of feed by the stock will be affected;
- Site staff will monitor all feeding operations at the facility. Feeding equipment must be regularly monitored during operations. Staff will closely observe fish feeding behavior;
- The use of underwater video cameras to monitor the feeding activity is recommended for all sites and will be used when available or when required;
- Feeding rates should be reduced or stopped when staff observes changes in fish activity indicating a reduction in appetite and/or if uneaten feed is detected passing through the bottom of the cage nets;
- Feeding will be temporarily reduced or suspended at times of strong currents flowing through the net pens that impact the ability of the fish to efficiently eat the feed;
- Hand feeding will be conducted in a manner to ensure an even distribution and reduce the amount of waste feed. Feeding will be slowed or paused if staff observes a reduction in feeding activity;
- Feeding performed with feed blowers will be conducted in a manner to ensure minimum loss of uneaten fish feed. Feeding will be slowed or paused if staff observes a reduction in feeding activity;
- Feeding equipment must be properly maintained to minimize crushing of the feed pellets which can result in fine feed dust that will not be eaten by the fish. The operator must establish a schedule for the regular maintenance of mechanical feed blowers;
- Mechanical feed blower nozzles must be carefully aimed and controlled to ensure that the feed is being evenly distributed across the surface of the net pen and that no feed is missing the net pen entirely;
- Computer-controlled feeding systems require that a qualified operator be on duty at all times when feed is being administered;
- Detailed records will be maintained for each cage of feed type and amount, fish numbers, total fish biomass, water temperature, and growth rates to ensure optimal feed conversion rates are being achieved at the site, minimizing feed losses;
- Feeding of moist feed will be conducted slowly to ensure that the fish have adequate time to consume the feed being distributed in the net pens;
- Feeding will be timed to coincide with the times of the day that the fish are eating well.
- Continual evaluation of the size of the pellets being used to feed the fish to ensure that the proper size pellets are being utilized; and
- All staff must be trained in the above practices. Detailed records of training must be maintained for each employee including training received and dates of training.

APPENDIX B: Examples of Mitigation Plans and Submissions

Environmental Impact: Stocking of Cages

Overstocking of the site or specific areas within the site, can lead to increased organic loading on certain parts of the site.

Enhanced Mitigation Measures

- A cage stocking strategy that helps to ensure oxic conditions based on the results of the environmental monitoring;
- Adjustment of the on-site cage stocking levels based on the environmental monitoring results; and
- Adjustment of the cage position based on the environmental monitoring results.
- How this will be monitored to prevent recurrence

Environmental Impact: Increased Faecal Matter

The settlement of faecal matter on the bottom of the lease can result in increased organic loading and impact the condition of the bottom sediment.

Enhanced Mitigation Measures

- Completion of a tidal current study through the deployment of a current meter on the lease for thirty-five days. The operator should evaluate the tidal patterns on both the overall site and at the individual cages using modelling. The use of the current meter and modelling studies will allow the operator to fully understand the dispersion of organic matter that is released from the farm operation;
- Adjustment in cage stocking levels based on the monitoring results;
- Adjustment in cage stocking levels based on the evaluation of tidal current patterns and modelling study;
- Adjustment in the cage positions on the lease according to monitoring results;
- Adjustment in the cage positions on the lease based on the tidal current study and modelling study during the grow out period;
- Modification to the harvest schedule to reduce biomass on the lease over those areas of the lease with greatest amount of degradation;
- Readjustment of the cages during the subsequent production cycles to avoid further impacts to areas showing adverse environmental conditions;
- Increase in the fallow period of the site to allow the site to recover; and
- Conduct an audit of site operations in addition to any regular scheduled auditing. This audit should be completed by an internal site manager working for the same operator at a different farm location. The auditor will examine the waste management practices employed on the site. A written report identifying any deficiencies observed as well as any recommendations to improve waste management practices is to be submitted to NSDFA by the auditor.
- How this will be monitored to prevent recurrence

Environmental Impact: Net Cleaning

When net cleaning occurs on a lease it can lead to a large release of biofouling from the nets which can settle on the bottom.

Enhanced Mitigation Measures

- Increase frequency of site cleaning practices to reduce amount of biofouling;
- Monitor and record the amount and frequency of biofouling over a set period and adjust net cleaning procedures to address biofouling accumulation;
- Evaluate site staff in terms of experience, qualification and awareness of site policies and procedures- increase staff training if necessary;
- Ensure all net cleaning equipment is maintained and remains in good working order. Ensure records are kept of the equipment maintenance schedules;
- Use of alternative methods on site to reduce the amount of biofouling that occurs;
- Creation and implementation of a standard operating procedure regarding the level of biofouling that is acceptable on a net cage and when net cleaning must occur;
- More frequent net changes when net washing is not feasible; and
- Conduct an audit of site operations in addition to any regular scheduled auditing. This audit should be completed by an internal site manager who works for the same operator at a different farm location. The auditor will examine the net cleaning practices used on the lease. A written report identifying any deficiencies observed as well as any recommendations to improve net cleaning practices is to be submitted to NSDFA by the auditor.
- How this will be monitored to prevent recurrence

Environmental Impact: Feeding

Improper feeding techniques can lead to the settlement of feed on the bottom of the lease, can lead to increased organic loading on the site.

Enhanced Mitigation Measures

- Evaluation of the site staff in terms of experience, qualifications and awareness of site policies and procedures;
- Update staff training on feeding methods when necessary;
- Compare feeding activities of the fish, feed conversion rates, and feed usage per cage for cages fed moist feed and dry feed to determine if the switch can be made earlier;
- Evaluate feed records to confirm the switch to dry feed is being made at the correct time according to the critical limit defined by the operator;
- Implementation of an equipment maintenance schedule if not in place;
- Implementation of a weekly maintenance schedule of on- site feed equipment. Ensure that all equipment used for feeding is kept in good working order;
- Increase record keeping from weekly records to daily records;
- Review the camera settings on site;
- Calibration of the feeding equipment; and

- Conduct an audit of site operations in addition to any regular scheduled auditing. This audit should be completed by an internal site manager who works for the same operator at a different farm location. The auditor will examine feeding practices used on the lease. A written report identifying any deficiencies observed as well as any recommendations to improve feeding is to be submitted to NSDFA by the auditor.
- How this will be monitored to prevent recurrence

Environmental Impact: Overfeeding

Overfeeding of fish can lead to the settlement of uneaten feed on the bottom of the aquaculture site.

Enhanced Mitigation Measures

- Calculate the weekly anticipated feed rate;
- Increased record keeping on the lease to monitor the weekly feed rate- compare to the calculated weekly feed rate;
- Adjust weekly feed rates to ensure it is not over the weekly feed rate;
- Increase staff training; and
- Conduct an audit of site operations in addition to any regular scheduled auditing. This audit should be completed by an internal site manager who works for the same operator at a different farm location. The auditor will examine feeding practices used on the lease. A written report identifying any deficiencies observed as well as any recommendations to improve feeding is to be submitted to NSDFA by the auditor.
- How this will be monitored to prevent recurrence

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