PLACENTIA BAY ATLANTIC SALMON AQUACULTURE PROJECT ENVIRONMENTAL EFFECTS MONITORING PLAN (EEMP): BENTHIC HABITAT HEALTH

GRIEG NL

June 2019

Placentia Bay Atlantic Salmon Aquaculture Project
Environmental Effects Monitoring Plan:

Benthic Habitat Health

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1.0 Introduction

As part of the environmental assessment (EA) process for the Placentia Bay Atlantic Salmon Aquaculture Project, Grieg NL was required to prepare and submit Environmental Effects Monitoring Plans (EEMPs) subsequent to the completion of the Environmental Impact Statement (EIS) but prior to initiation of Project construction (see Section 7.4 in EIS Guidelines, Department of Municipal Affairs and Environment [DMAE] 2018). Additionally, the release of the Placentia Bay Atlantic Salmon Aquaculture Project from further environmental assessment by DMAE on 5 September 2018 was subject to Grieg NL meeting a series of terms and conditions including eight components requiring an EEMP. The EEMP for the Benthic Habitat Health component is presented in this document. This EEMP is designed to monitor nutrification effects on benthic habitat due to the deposition of fish feces, uneaten fish feed, and naturally occurring biofouling material from sea cages (i.e., biochemical oxygen demand [BOD] matter). The EEMP is largely based upon and designed to meet the most recent *Aquaculture Activities Regulations* (*AAR*) (2019).

Grieg NL is committed to implementation of this EEMP as an essential component of its Placentia Bay Atlantic Salmon Aquaculture Project. The organization of this document closely follows the requirements outlined in Section 7.4 of the EIS Guidelines (DMAE 2018). The EEMP will be reviewed on an annual basis and updated as-needed throughout the Project life.

2.0 Objectives and Scheduling of Monitoring

The objective of the EEMP for 'Benthic Habitat Health' is to evaluate for nutrification effects due to the deposition of BOD matter (i.e., fish feces, uneaten fish feed, and naturally occurring biofouling material) from sea cages to the seabed in the vicinity of the cages during aquaculture operations. Monitoring is designed to ensure that the deposition of BOD matter does not exceed regulatory thresholds (as stipulated in the *AAR*) such that effects on benthic habitat are minimized to the extent possible. Monitoring can be conducted with either sediment sampling or visual monitoring depending on bottom type. The indicators of threshold exceedance are as follow:

For sediment sampling:

- mean concentration of free sulfide in surficial sediment collected at any particular lease site exceeding 3000 µM.

For visual monitoring:

- the presence of *Beggiatoa* species or similar bacteria at more than 70% of the visual monitoring stations;
- the presence of marine worms at more than 70% of the visual monitoring stations; and/or
- the presence of barren substrate at more than 70% of the visual monitoring stations.

This EEMP is largely based on three documents; (1) the *Aquaculture Activities Regulations* (*AAR*) (current to 30 January 2019) made pursuant to the Ministerial regulation-making authorities as stated in Sections 35(3) and 36(5.2) of the *Fisheries Act*; (2) the *AAR* guidance document available on the Fisheries and Oceans Canada (DFO) website (http://www.dfo-mpo.gc.ca/aquaculture/management-gestion/aar-raa-gd-eng.htm), specifically Annex 7 (Visual Recording Procedures) and Annex 9 (NL Monitoring

Protocol); and (3) the *AAR* Monitoring Standard 2018 (DFO 2018) (Appendix 1), which supports the monitoring and sampling requirements of the *AAR*. These three documents provide the necessary level of detail to enable Grieg NL to produce consistent and high-quality data associated with the benthic habitat.

The *AAR* and associated guidance document state that when possible, monitoring of benthic habitat at sea cage sites should be conducted via grab sampling to acquire appropriate sediment samples. If hard substrate dominates (i.e., >50% of the "lease area" is hard bottom composed of rockwall, bedrock, boulders, rubble, cobble, gravel or hard-packed finer substrates) at any lease site making grab sampling impractical, then visual monitoring of the seabed will be conducted. Regardless of the classification of the seabed, Grieg NL commits to following the *AAR* protocol, as indicated in Section 7.8 of the EIS. Either visual monitoring using an underwater camera (i.e., remotely operated vehicle [ROV] or drop camera) or benthic sediment sampling using a grab sampler will be conducted at the lease sites at least once during a production cycle at sea (i.e., 16–17 months) between 1 July and 31 October at a time close to peak feeding when water and weather conditions minimize adverse effects on the sampling quality (DFO 2018). Note that neither visual nor physical sediment monitoring is required within the 1 g C/m^2/day depositional contour where water depths exceed 300 m. The 1 g C/m^2/day depositional contour will be based upon modelling conducted for each sea cage site using up to one year of data inputs.

3.0 Monitoring Design/Methodology

As indicated in the *AAR*, monitoring by either video surveying or benthic sediment sampling must be conducted at any particular sea cage lease site at least once during the production cycle. Benthic monitoring will be conducted between 1 July and 31 October during peak feeding of the farmed salmon, during times when water and weather conditions minimize adverse effects on sampling quality and facilitate accurate sampling at each station. If benthic monitoring conducted during peak feeding finds indicators of threshold exceedance, then additional habitat health monitoring will be required, and no fish restocking will occur at that specific site until sampling results return to accepted levels.

3.1 Monitoring Transects and Stations

Regardless of the monitoring type (i.e., benthic sediment sampling or visual surveying), the configurations of the monitoring transects/stations are the same. Below are descriptions of the two configurations based on the number of sea cages in a row.

For lease sites that include more than nine sea cages in a row (i.e., those in Rushoon, Merasheen and Red Island Bay Management Areas (BMAs) during full production), monitoring will be conducted along eight transects, each one extending 100 m from the sea cage "string" within the predicted or anticipated zone of effect of deposition of organic waste from the sea cages (i.e., 1 g C/m^2/day depositional contour determined through modelling). Three transects will originate from each end of the string of sea cages, and two will originate from a sea cage located near the middle of the string. Benthic monitoring stations will be located at 0-m (i.e., at edge of sea cage), 20-m, 40-m, 60-m, 80-m, and 100-m along each transect (Figure 1).

For lease sites with less than nine cages in a row (i.e., each of the two lease sites in the Long Harbour BMA and during ramp-up periods in Rushoon, Merasheen and Red Island BMAs), monitoring will be conducted along six transects. Each transect will extend 100 m from the sea cage string within the

predicted or anticipated zone of effect of deposition of organic waste from the sea cages. Three transects will originate from each end of the string of sea cages. Benthic monitoring stations will be located at 0-m (i.e., at edge of sea cage), 20-m, 40-m, 60-m, 80-m, and 100-m along each transect (Figure 2).

At least one reference station will be monitored in conjunction with the monitoring of the benthic habitat health at each sea cage site. The reference station will be either another 100-m transect oriented outward from the lease boundary or discrete stations that are not exposed to BOD matter deposited from the sea cages. Water depth(s) at the reference station will be within 10 m of the range of depths associated with the sampling stations along the monitoring transects originating at the sea cage "string". The topography, seabed type, current and tidal regimes, sediment grain size and the amount of freshwater runoff influence associated with the reference station will be representative of the sampling stations. The reference station will be located in the same contiguous body of water within which the benthic monitoring stations occur.

3.2 Visual Monitoring

Visual monitoring of the benthic substrate at Grieg NL sea cage lease sites classified as having >50% hard bottom will adhere to the following procedures stipulated in the *AAR* and its guidance document.

- A drop still camera or a diver-operated/towed/remotely-operated video camera will be used;
- The weight of towed devices will allow for stable movement at a consistent water depth without disturbing the surficial sediment;
- Lights associated with the camera will illuminate the benthic substrate to an intensity balanced to the optical sensitivity of the lens such that a uniform field of view is visible;
- Optical resolution of the camera will be sufficient such that organisms >1 cm in size can be distinguished by the unaided eye and identified in a 0.5 m x 0.5 m horizontal field of view. Magnification of species observed is acceptable for identification purposes;
- Video will be well balanced in terms of image focus, clarity, colour balance and lighting;
- Diver-operated/towed/remotely-operated video cameras will be operated at a constant velocity that allows accurate identification of visual parameters;
- Original video will be transferred to digital format storage media with no post-survey video editing;
- At least one reference station will be visually monitored in conjunction with the monitoring of the benthic habitat health at each sea cage site. The reference station will be either another 100-m transect oriented outward from the lease boundary or discrete stations that are not exposed to BOD matter deposited from the sea cages. Water depth(s) at the reference station will be within 10 m of the range of depths associated with the sampling stations along the visual monitoring transects originating at the sea cage "string". The topography, seabed type, current and tidal regimes, sediment grain size and the amount of freshwater runoff influence associated with the reference station should be representative of the sampling stations. The reference station should be located in the same contiguous body of water within which the visual monitoring stations occur;

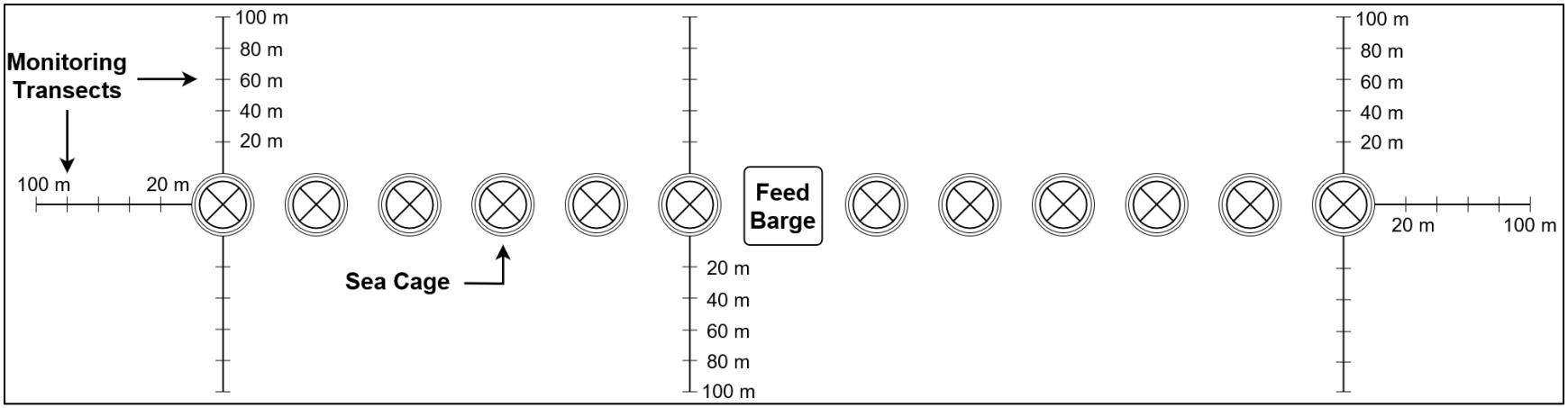

Figure 1. Locations of benthic monitoring transects for an example of more than nine sea cages in a row.

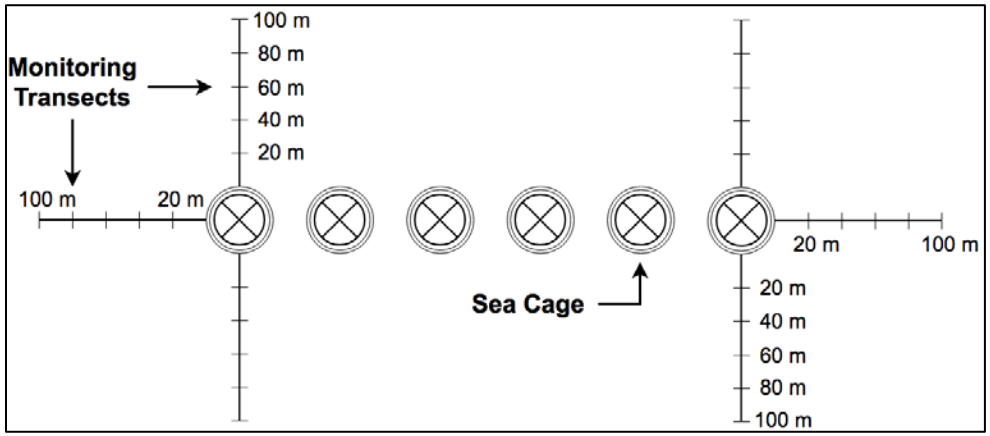

Figure 2. Locations of benthic monitoring transects for an example of less than nine sea cages in a row.

- Visual monitoring will be conducted at times when water and weather conditions minimize adverse effects on monitoring quality and facilitate accurate monitoring at the sampling stations (e.g., slack tide, low wind conditions, good visibility). In addition, visual monitoring will be conducted during the period of actual or predicted maximum daily quantity of feed usage during the production cycle at any particular sea cage site;
- Video will record the date and be accurately referenced such that an individual viewing the video can appreciate conditions at each sampling location; and
- Visual monitoring will not be undertaken on any site during any disease outbreak or recovery period as determined in consultation with the Department of Fisheries and Land Resources (DFLR) Aquatic Animal Health Division.

The visual monitoring will be conducted in accordance with the DFO Standard Operating Procedure (SOP) for Underwater Video Camera System (DFO 2012) (see Appendix 2). The purpose of the SOP is to outline the minimum requirements for collecting high quality underwater video, and to standardize data recording and subsequent analysis.

Either a drop camera or ROV will be used for visual monitoring. If using a drop camera, at each of the six sampling stations along each transect, the camera system will be lowered to the substrate and left for at least 10 seconds to ensure a clear image for video analysis. The camera system will then be raised about 30 cm and re-lowered to the substrate to confirm benthic type. The zoom function, if available on the camera, will be used. The number of recordings at each station is dependent on the resolution required for analysis. If a number of recordings are required, then the camera system will be lifted about 30 cm above bottom and moved slightly to document an adjacent area. Once a station has been fully recorded, the entire camera system will be raised to surface, the sampling platform (i.e., boat) moved to the next station, and the camera system will be lowered to the substrate. Note that the boat operation is critical for the 'drop sampling' procedure. If feasible, each transect station will be marked with a moored surface float prior to conducting the survey. This way the boat can be tethered to each station mooring during visual monitoring, thereby ensuring that stations being sampled are consistent. If using a ROV for visual monitoring, the device will be weighted to allow for stable movement at a consistent depth and velocity without disturbing sediment substrate while permitting accurate identification of visual parameters. Coordinates will be established by a dGPS at the start and finish of each transect.

Information derived from analysis of the visual monitoring data will be entered into the 'Visual BOD Monitoring Data Template'; an Excel file available at http://www.dfo-mpo.gc.ca/aquaculture/management-gestion/aar-raa-eng.htm.

3.3 Benthic Sediment Sampling

3.3.1 *AAR* Monitoring, Biochemical Oxygen Demand Matter

Benthic sediment sampling at Grieg NL sea cage lease sites classified as having <50% hard bottom will adhere to the following procedures stipulated in the *AAR* and its guidance document. Grieg NL will attempt to obtain benthic sediment samples with a grab sampler to a depth of at least 5 cm and with a volume of at least 15 mL of undisturbed sediment-seawater interface water, as required in the *AAR*.

- dGPS coordinates will be measured at each corner of the sea cage array and at all sampling stations. Coordinates will be recorded in decimal degrees or Universal Transverse Mercator (UTM) using the North American Datum of 1983 as reference.
- The sampling device (e.g., Ponar grab) will be of appropriate weight and size to ensure that the decent of the sampling device is vertical and directly below the deployment platform (i.e., minimal scope on sampling device line).
- At least three surficial sediment samples will be collected at each station. Surficial sediment sampling will be abandoned at any particular station after five failed attempts.
- There must be overlying water (i.e., seawater at the interface between seabed and water column) associated with the samples. This overlying water will be siphoned from the sampling device prior to processing the surficial sediment part of the sample.
- The overlying water must be clear and not excessively turbid.
- The surficial sediment-seawater interface must be intact and relatively flat, without any sign of channeling or sample washout.
- There must be minimal sediment loss from the sampling device.
- Successive samples will be collected from surficial sediment undisturbed by previous sampling.
- Excess sediment from samples will be disposed of in a manner that minimizes the possibility of contaminating subsequent samples.
- One subsample that is representative of the upper 2 cm of surficial sediment in the sampler will be collected.
- All non-sedimentary material (e.g., large shell fragments, wood waste, rock, fish) will be removed from each surficial sediment sample prior to removing sediment for analysis.
- The sampler will be kept level during sample processing.
- Overlying water will be removed from each surficial sediment sample immediately, and sediment subsampling will not be conducted anywhere with remaining overlying water.
- The sampler will not be overfilled which could result in the upper portion of the sample coming into contact with the sampler.
- All attempts at surficial sediment sampling will be clearly documented by video or still photography to support sampling approach acceptability criteria.
- The following information related to the seabed will be collected at each sampling station:
    - latitude and longitude using dGPS;
    - water depth;
    - date and time of sampling;
    - sediment texture and colour;
    - photograph of the sediment sample;
    - absence/presence of gas bubbles;
    - estimated surface coverage by bacterial mats;
    - estimated surface coverage by marine worms;
    - absence/presence of fish feces and feed;
    - absence/presence of flocculent organic material;
    - free sulfide level;
    - redox measurement; and
    - percent organic material and porosity.

- Any benthic sediment samples will be analyzed in a certified analytical laboratory. There must be full compliance with the following procedures when measuring the concentrations of free sulfide and redox in the sediment samples:
    - Concentrations of free sulfide must be determined within 36 hours of sample collection;
    - Subsamples for free sulfide concentration determination must be stored at temperatures ranging from 2–5°C;
    - Free sulfide concentration must be determined using a silver/sulfide probe with a sulfide sensitivity range of at least 0–19,900 µM, an accuracy of ±5% with an appropriate ion-selective electrode (ISE) or millivolt (mV) meter with a resolution of 0.1 mV;
    - The silver/sulfide probe must be calibrated using three to five serial dilutions of a standard sulfide solution, beginning with the most dilute solution;
    - Redox measurements must be conducted as follows:
        - The redox combination electrode must have an appropriate ISE or mV meter;
        - The probe must be fully calibrated prior to conducting measurements; and
        - Redox values and temperature must be measured at the same time as the free sulfide measurement.

Information derived from analysis of the benthic sediment samples will be entered into the 'Sediment BOD Monitoring Data Template'; an Excel file available at http://www.dfo-mpo.gc.ca/aquaculture/management-gestation/aar-raa-eng.htm.

3.3.2 Monitoring Deposits of Deleterious Substances Other Than BOD Matter

As described in Section 2.5.2.2, *Fish Health* of the EIS and Grieg NL's Fish Health Management Plan, the use of therapeutants to minimize sea lice, is considered a last resort relative to a suite of other mitigation measures (e.g., cleaner fish, sea lice skirt, sub-feeder, functional feed). With regard to antibiotic use, fish populations do not receive antibiotics in the absence of disease, but medications can be used to minimize, and to some extent mitigate, disease events that veterinarians recognize seasonally or can arise following a stressor.

Although Grieg NL will attempt to avoid the use of drugs and pesticides, the use of any drugs or pesticides by Grieg NL will be regulated and require approval. The *AAR* (Section 3) authorizes only deposits of (a) drugs whose sale is permitted or otherwise authorized, or whose importation is not prohibited under the *Food and Drug Act* (FDA) and; (b) pest control products that are registered, or whose use is authorized under the *Pest Control Products Act* (PCPA). In addition, conditions in Sections 4 through 14 of the *AAR* must be met. To be authorized, the deposit of a substance during treatment must be in compliance with other laws, including the federal FDA and PCPA. If the substance is a drug, its sale must be in compliance with the federal FDA and if it is a prescription drug under the FDA, the drug must be prescribed by a veterinarian. If the substance is a pest control product (pesticide), its use must be in compliance with the PCPA.

Recognizing the reduced level of certainty around effects predictions related to the potential use of therapeutants on the Fish and Fish Habitat Valued Environment Component (VEC), Grieg NL will collect, where possible, samples of the deposited organic material in the vicinity of the sea cages and analyze the samples for presence of chemicals found in these substances, if registered drugs or pesticides have to be used. Fauna may also be collected and analyzed to determine a sense of bioavailability of the substances. Procedures for sample collection will be determined in consultation with DFO. These data will provide information about the quantity and persistence of these chemicals on the seabed.

4.0 Frequency, Duration and Geographic Extent of Monitoring

The frequency, duration, and geographic extent of benthic habitat health monitoring are determined based on requirements in the *AAR* (2019).

4.1 Frequency

Benthic monitoring, either through visual surveying or benthic sediment sampling, will be conducted at any particular sea cage site (as well as the associated reference site) at least once during a production cycle at sea (i.e., 16–17 months). This monitoring will be conducted between 1 July and 31 October at a time close to peak fish feeding when water and weather conditions minimize adverse effects on the sampling quality (DFO 2018). If benthic monitoring conducted during peak feeding finds indicators of threshold exceedance, then additional habitat health monitoring will be required, and no restocking will occur at that specific site until sampling results return to accepted levels. Monitoring will be conducted throughout the life of the Project.

4.2 Duration

It is anticipated that a single benthic monitoring event at a sea cage site will require two to three days to complete, weather permitting. Analysis of the video will occur in the office, and analyses of sediment samples will be conducted in a certified analytical laboratory. Data will be included in the annual report (see Section 5.0).

4.3 Geographic Extent

Monitoring of benthic habitat health will be conducted at all sea cage sites throughout the life of the Project. For each sea cage site that includes a string of more than nine cages, a monitoring event will include eight 100-m transects (see Figure 1) with sampling stations at 0-m, 20-m, 40-m, 60-m, 80-m and 100-m locations along each transect. For each sea cage site that will include a string of less than nine cages, a monitoring event will include six 100-m transects (see Figure 2) with sampling stations at 0-m, 20-m, 40-m, 60-m, 80-m and 100-m locations along each transect. These transect locations and lengths ensure that the benthic monitoring being conducted at each sampling station is within the depositional effects zone determined by modelling. In addition, each sea cage site will have a designated reference transect that is located outside of the predicted depositional effects zone and is also characterized by six sampling stations.

5.0 Reporting and Response Mechanisms

5.1 Biochemical Oxygen Demand Matter

Should results of benthic sediment sampling indicate that the mean concentration of free sulfide in surficial sediment collected at any particular lease site exceeds 3000 µM (through sediment sample analysis) or results of visual monitoring indicate the occurrence of *Beggiatoa* species or similar bacteria, marine worms or barren substrate at more than 70% of the specified locations, the Minister of DFO will be notified. Notification of the Minister will occur within 14 days after the day in which monitoring was conducted as specified in *AAR* (12(3)). In addition, an annual report will be submitted to the DFO Minister and/or Regional Aquaculture Management Office on or before 1 April of the year following the benthic habitat health monitoring. As per Section 16 of the *AAR*, this report will follow the Annual Report for Marine Cage Finfish Operations Template in Annex 1 of the *AAR* (http://www.dfo-mpo.gc.ca/aquaculture/management-gestion/doc/2016-aar-rt-marine-freshwater-eng.pdf). The report of operational monitoring results associated with the benthic habitat health will include, at a minimum, the following:

- The observations recorded from the underwater surveys, including the unedited recorded images and will be documented in the *AAR* Visual BOD Monitoring Template;
- A map showing locations of transects and habitat information generated during the transect surveys at a minimum resolution of 1:5,000, bathymetry of the seabed at a resolution of 10 m contours, and the estimated footprint of deposition of BOD matter in 1, 5, and 10 g C/m^2/day contours; and
- Unedited visual recordings with the following information types will be submitted.
    - Positional data including all start and stop locations and all waypoints between using GPS;
    - Ocean depth at the location of video recording at 10 m intervals;
    - Date and time of sampling;
    - Estimate of surface coverage of bacterial mats; and
    - Estimate of surface coverage of marine worms.
- The submitted visual recordings will be accompanied by completed information tables (see Appendix 1 of Annex 9 of the *AAR* guidance document or Visual BOD Monitoring Template *AAR* [http://www.dfo-mpo.gc.ca/aquaculture/management-gestion/aar-raa-eng.htm]) that include but are not limited to descriptions of the exact sea cage site location, images on the videography, the depth of water below each sea cage, and the locations of the video images at each sea cage. Appendix 1 of Annex 9 of the *AAR* guidance document provides a full list of the variables for which information is required in the reporting tables.

With respect to criteria for response mechanism, Grieg NL, in consultation with DFO and DFLR, will not restock a given sea cage site (i.e., will implement an extended period of fallowing) if the monitoring of the benthic habitat at that sea cage site indicates threshold exceedance as a result of organic enrichment from deposits associated with aquaculture activity. If *AAR* thresholds are exceeded, then Grieg NL commits to an adaptive management approach to address these issues. As indicated in Section 7.8 of the EIS, additional benthic monitoring will be implemented, and either existing mitigation measures will be adjusted, or new mitigation measures will be implemented. Any additional monitoring will use the same

methodology described in Section 3.0 of this EEMP. The additional benthic monitoring will continue until the monitoring criteria are no longer exceeded.

5.2 Deposits of Deleterious Substances such as Drugs or Pesticides

As part of its annual report that is to be submitted to the Minister (*AAR* Section 14), Grieg NL is required to provide the following information in respect of the operation of the aquaculture facility during the calendar year (*AAR* S. 16 (1) (a)) for drugs or pesticides:

a) For each deposit of a drug or pest control product during the year
    a. The product name of the drug or pest control product or the common chemical names of its active ingredients;
    b. The purpose of the deposit;
    c. The date, quantity and geographic coordinates of the deposit; and
    d. The record of alternatives referred to in paragraph 5(c) or 6(c) of the *AAR*.

Grieg NL will utilize the *AAR* Reporting Template in Annex 1 of the *AAR* to submit to the Regional Aquaculture Management Office by 1 April or three months following the end of the year being reported.

6.0 Approach to Monitor Cumulative Effects

Benthic monitoring will be periodically conducted at all sea cage sites during the life of the Project as required by *AAR* and as such, the cumulative effects of the deposition of organic matter from the sea cages onto the seabed can be determined. Grieg NL will present in its annual report (see Section 5.0) a summary of changes in benthic habitat health as determined by monitoring at all of its sea cage sites. This will provide an indication of the cumulative effects of the Project on benthic habitat health.

7.0 Procedures to Assess Effectiveness of Monitoring Programs, Mitigation Measures, and Recovery Programs

If monitoring of the benthic habitat indicates that there is an accumulation of organic matter on the seabed, as evidenced by the mean concentration of free sulfide in sediment samples exceeding 3000 µM or the occurrence of *Beggiatoa* species or similar bacteria, marine worms or barren substrate at more than 70% of the specified locations (i.e., threshold exceedance), then additional monitoring will have to be conducted at the stations until the monitoring criteria are below threshold exceedance. No fish restocking of these sites will occur until benthic habitat health conditions are suitable.

8.0 Communication Plan to Describe the Results

As per Section 16 of the AAR, an annual report will be submitted to DFO's Regional Aquaculture Management Office on or before 1 April of the year following benthic habitat health monitoring. This report will follow the Annual Report for Marine Cage Finfish Operations Template *AAR* (http://www.dfo-mpo.gc.ca/aquaculture/management-gestion/doc/2016-aar-rt-marine-freshwater-eng.pdf). A copy of this report will be retained by Grieg NL for a period of two years from the day it is submitted as required by the *AAR*.

As per 'Condition c' in the Government of Newfoundland and Labrador's Project release letter, Grieg NL will include the results of the benthic habitat health monitoring within its annual report on EEMPs.[1] This report will be publicly available on the Grieg NL website.

9.0 Literature Cited

DFO. 2012. Standard Operating Procedure (SOP) for Underwater Video Camera System. 17 p. + appendices.

DFO. 2019. *AAR* Monitoring Standard 2019. 12 p. Available at DFO website http://www.dfo-mpo.gc.ca/aquaculture/management-gestion/aar-raa-eng.htm

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Government of Canada (Minister of Justice). 2018. Aquaculture Activities Regulations. SOR/2015-177. Current to November 20, 2018. Available at https://laws-lois.justice.gc.ca/eng/regulations/SOR-2015-177/page-1.html

List of Appendices:

Appendix 1 – *AAR* Monitoring Standard (2018)

Appendix 2 – Standard Operating Procedure for Underwater Video Camera System

[1] Grieg NL will publicly release all confirmed reports of disease and fish escapes within 24 hours and the use of chemotherapeutants (i.e., antibiotics, vaccinations, and anesthetics) and pesticides on an annual basis.

Appendix 1

AAR Monitoring Standard (2018)

AAR
Monitoring Standard
2018

Introduction

This Aquaculture Monitoring Standard (Monitoring Standard) will support the monitoring and sampling requirements of the *Aquaculture Activities Regulations* (AAR) under the *Fisheries Act*. This document provides the necessary level of detail to enable the owner or operator of an aquaculture facility to produce to the greatest extent possible, consistent and high quality data to support the implementation of the AAR.

This Monitoring Standard will be amended (in consultation with provinces) from time to time.

The most current version of the Monitoring Standard is available on the Fisheries and Oceans Canada (DFO) website http://www.dfo-mpo.gc.ca/aquaculture/management-gestion/aar-raa-eng.htm

Definitions

"Containment Array" means an assembly of interconnected cages used to cultivate fish.

"Marine Worms" mean aggregates of opportunistic polychaetes that colonize organically enriched substrates.

"Reference Station" means a sampling station chosen to represent a background or natural state. Reference stations may be chosen as discrete sampling locations or contained along a transect representing a traditional "gradient" to "background" approach.

"Sampling Station" means a location where recording is carried out and any samples are collected.

"Soft Bottom Site" means, further to definition in AAR, a site where acceptable samples can be taken from the benthic substrate based on the grab acceptability criteria and sampler options related to oceanographic conditions and substrate type or classified as soft bottom based on provincial criteria.

"Transect" means a directional line, along which sampling stations are established or visual observations are made.

I. Survey for Baseline Information for New Sites and Expansion of Existing Sites [AAR section 8 and 9]

Predicted Contours [AAR paragraph 8(1)(*a*)]

1. (1) Calculate the rate of deposition of biochemical oxygen demanding (BOD) matter from the facility during maximum daily quantity of feed usage, using an aquaculture waste deposition model, and map the 1, 5, and 10 grams carbon per meter squared per day (g C/m^2/day) depositional contours.

(2) Site-specific oceanographic data will be used for model inputs. Using an aquaculture waste deposition model, input characteristics for food and fecal waste must be either accepted international standard values or operator measurements. Model simulations are not to include estimates of post-deposition particle resuspension.

Survey of Fish and Fish Habitat [AAR paragraph 8(1)(b)]

2. (1) When conducting surveys of fish and fish habitat, sampling stations along a transect or within a grid must be representative of the different physical/biological characteristics of the bottom habitat within the modeled 1 g C/m^2/day depositional contour and the entire lease, including reference stations where applicable.

(2) Sampling is not required within areas of the tenure or 1 g C/m^2/day depositional contour where depths exceed 300 m.

(3) If historical fish and fish habitat data for an expanded lease area demonstrates a homogeneous coverage of mud or sandy habitat, then only one video transect across the width of the entire lease in the direction of the dominant current and under the proposed array location is required.

(4) The fish and fish habitat benthic survey is to be conducted to identify species that are 1 cm or greater in length and the type of habitat present.

(5) All fish habitats/substrates must be identified.

Bathymetry Survey [AAR paragraph 8(1)(c)]

3. (1) A bathymetric survey must be conducted with a minimum resolution of 10 m contours to generate depth profiles, related to chart datum, within the modeled 1 g C/m^2/day depositional contour, as calculated in subsection 1(1), and covering the entire lease, including reference stations where applicable.

(2) Despite subsection 3(1), a bathymetric chart from the Canadian Hydrographic Service that includes depth profile contours in 10 m increments may be used instead of conducting a bathymetric survey**.**

(3) Echosounders, transducers, and associated equipment used to generate the bathymetric survey in subsection 3(1) must be calibrated to industry standards.

(4) Horizontal position fixing measurements must be carried out using a differential Global Positioning System (dGPS).

Benthic Substrate Monitoring [AAR paragraph 8(1)(d)]

4. (1) Information concerning the seabed will be collected within locations representative of the entire lease and the modeled 1 g C/m^2/day depositional contour, as calculated in subsection 1(1), including reference stations where applicable.

(2) In the case of an aquaculture facility that is located in tidal waters in or adjacent to:

(a) Quebec, Nova Scotia, New Brunswick, Prince Edward Island or Newfoundland and Labrador, collect samples of the benthic substrate in the center and at each corner of the lease boundary;

(b) New Brunswick, collect samples of the benthic substrate at the end of a 50 m transect from the lease boundary, in the direction of the dominant current;

(c) Quebec, Nova Scotia, or Prince Edward Island, collect samples of the benthic substrate between 100 to 300 m from the edge of the lease boundary, in the direction of the dominant current;

(d) British Columbia, collect samples of the benthic substrate at a minimum of two sampling stations (30 m and 125 m away from the cage edge) along two transects that align with the area of greatest predicted impact and with the dominant and sub-dominant current directions;

(e) If the containment array mentioned in paragraph 4(2)(d) is greater than 200 m in length and its long axis is perpendicular to the direction of the dominant current, additional sampling is required in the following manner:

(i) for every 200 m increment in length, establish additional transects with sampling stations at 30 and 125 m adjacent to each transect established in paragraph 4(2)(d);

(ii) transects must be parallel to each other and a minimum of 50 m apart;

(iii) based on the 5 g C/m^2/day contour, as calculated in subsection 1(1), the transects are to be located in the direction of maximum deposition as determined by the 5 g C/m^2/day contour.

(3) In addition to the criteria specified in the AAR subsection 10(2), the following relevant criteria must be complied with for benthic substrate sampling using grab or core devices :

(a) Obtain dGPS coordinates at each corner of the containment structure array and at all sampling stations, Readings are to be recorded in decimal degrees or Universal Transverse Mercator coordinates, using the North American Datum of 1983 as reference;

(b) The sampling device shall be of a weight and size to ensure sampler decent is vertical and directly below the area of deployment with no evidence of drift (angle in line is not noted);

(c) Collect at least 3 samples from each station. At least 5 failed attempts per station must occur and be documented before sediment sampling is abandoned;

(d) Overlying water is present (indicates minimal leakage) and must be removed prior to processing and storage by siphoning, not decanting;

(e) The overlying water is clear or not excessively turbid;

(f) The sediment-water interface is intact and relatively flat, with no sign of channeling or sample washout;

(g) There is minimal sediment loss.

(h) Obtain successive samples from substrate that has not been disturbed by previous sampling;

(i) Dispose of excess sediment in a manner that minimizes the possibility of contaminating subsequent samples;

(j) Collect at least one subsample that is representative of the top 2 cm of sediment within the sampler;

(k) Remove all non-sedimentary material, including all large shell fragments, fish, wood waste, and rock, before placing material in containers for analyses;

(l) Keep sampler level when retaining samples;

(m) Remove overlying water quickly from sample and avoid areas for subsampling where any overlying water may remain;

(n) The sampler is not overfilled so that the sediment surface is touching the top of the sampler;

(o) The core sampler was not inserted at an angle or tilted upon retrieval;

(p) All sampler attempts and sediment collections must be clearly documented by video or still

pictures to support sampling approach acceptability criteria.

(4) The following information concerning the seabed must be collected with samples collected:

(a) latitude/longitude using dGPS;

(b) depth;

(c) date and time of sampling;

(d) sediment texture and colour;

(e) photo of sediment sample;

(f) presence of gas bubbles;

(g) estimation of surface coverage of bacterial mats;

(h) estimation of surface coverage marine worms;

(i) presence of fish feces and feed;

(j) presence of flocculent organic material;

(k) free sulfide;

(l) redox;

(m) sediment grain size; and,

(n) percent organic matter and porosity only in Quebec, Nova Scotia, New Brunswick, Prince Edward Island, and Newfoundland and Labrador; or,

(o) total volatile solids in British Columbia.

(5) The following procedures must be complied with when measuring the concentration of free sulfide, redox, and sediment grain size in sediment samples:

(a) The concentration of free sulfide in the sediment samples must be determined within 36 hours of collection, except in British Columbia where sediment samples must be analyzed within 5 minutes;

(b) If the free sulfide concentration measurements are not carried out within 5 minutes of the sample being collected, subsamples must be stored between 2 and 5 °C until they are analyzed;

(c) Use a silver/sulfide probe with a sulfide sensitivity range of at least 0 to 19,900 μM and a accuracy of ± 5 % with an appropriate ion-selective electrode (ISE) or millivolt (mV) meter of 0.1 mV resolution;

(d) The probe must be calibrated using three to five serial dilutions of a standard sulfide solution, as required, beginning with the most dilute solution ;

(e) Sediment grain size distribution measurements must be recorded according to the Wentworth grain size scale as a percentage of the total subsample mass;

(f) Redox measurements must be conducted in the following manner:

(i) The redox combination electrode must have an appropriate ISE or mV meter;

(ii) Calibration of the probe must be completed before measurements are taken, and;

(iii) Redox values and temperature must be measured at the same time as the free sulfide.

(6) Where samples cannot be obtained as specified in subsections 4(2) and (3), visual monitoring must be conducted as specified in sections 5 and 6.

Exception

(7) Sampling is not required within areas of the tenure or 1 g C/m^2/day depositional contour where depths exceed 300 m.

Visual monitoring procedures [AAR paragraph 11(2)(a), (b), and (c)]

5. (1) Visual monitoring of the benthic substrate must be conducted in the following manner:

(a) Must use a handheld or dropped still camera, or diver-operated, towed, or remotely operated video camera;

(b) The weight of towed devices must allow for stable movement at a consistent depth without disturbing sediment substrate;

(c) Cameras used for underwater photography must illuminate the benthic substrate to an intensity balanced to the optical sensitivity of the lens such that a uniform field of view is visible;

(d) The optical resolution of the camera lens must be sufficient that organisms greater than 1 cm in size can be distinguished by the unaided eye and identified in a 0.5 m x 0.5 m horizontal field of view; magnification of species observed is acceptable, as necessary, for identification purposes;

(e) Diver-operated, towed, or remotely operated video cameras must be operated at a constant velocity that permits accurate identification of visual parameters;

(f) Original video must be transferred to digital format storage media with no post-survey video editing.

Visual monitoring locations [AAR paragraph 11(2)(a)(b) and (c)]

6 (1) In the case of an aquaculture facility that is located in tidal waters in or adjacent to Quebec, Nova Scotia, New Brunswick, or Prince Edward Island, images will be taken at the same stations specified in paragraph 4(2)(a).

(2) In the case of an aquaculture facility that is located in tidal waters in or adjacent to Newfoundland and Labrador, images must be recorded based on a 100 m^2 grids within the lease. At least one station must be established at the edge of the proposed containment array (0 m).

(3) In the case of an aquaculture facility that is located in tidal waters in or adjacent to British Columbia, images must be recorded along two transects that start at the edge of the proposed containment array, align with the area of greatest predicted impact and with the dominant and sub-dominant current directions and extend for a minimum of 140 m, with a maximum deviation of ± 20% from that bearing. Images must also be collected from reference stations during baseline surveys.

(4) Coordinates as established by a dGPS must be noted at the start and finish of each transect. The readings must be recorded in degrees minutes decimal minutes with 3 digits following the decimal point, using the North American Datum of 1983 as reference.

Exception

(5) Sampling is not required within areas of the tenure or 1 g C/m^2/day depositional contour where depths exceed 300 m.

Timing of Sampling [AAR paragraph 8]

7. Benthic substrate surveys or visual monitoring must be conducted prior to the introduction of fish to the site.

Recording of Baseline Survey Information [AAR subsections 8(1) and (3), and 9(1)]

8. The report of the baseline survey findings must include at a minimum:

(a) The observations recorded from the underwater surveys, including the unedited recorded images;

(b) A map with the locations of transects and habitat information generated during these transects at a minimum resolution of 1:5000, the bathymetry of the seabed at a resolution of 10 m contours; and the estimated footprint of deposition of biochemical oxygen demanding matter in 1, 5, and 10 g C/m^2/day contours;

(c) The results of sediment sampling as specified in subsection 4(4) or records of failed sediment sampling attempts as per 3(c).

(d) Unedited visual recordings must be submitted with the following information:

(i) positional data including all start and stop points and way points in between using corrected dGPS;

(ii) ocean depth of the location recorded; and for continuous video depths at a minimum of 10 m intervals;

(iii) date and time of sampling;

(iv) estimation of surface coverage of bacterial mats; and,

(v) estimation of surface coverage of marine worms.

II Procedures for Operational Monitoring [AAR section 10(1)]

Timing of Sampling [AAR paragraphs 10(1)(*a*) and (*b*)]

9. Benthic monitoring samples or video must be taken at the facility at least once during the production cycle at sea or every 24 months for farms with finfish continuously on site:

(1) In British Columbia, within 30 days of peak feeding or peak biomass;

(2) In Quebec, Nova Scotia, New Brunswick, Prince Edward Island , or Newfoundland and Labrador, between July 1 and October 31, close to peak feeding;

(3) During times when water and weather conditions minimize adverse effects on sampling quality and facilitate accurate sampling at stations.

Benthic Substrate Monitoring [AAR paragraphs 10(1)(a) and (b)]

10. (1) Where benthic substrate monitoring is conducted, the procedures as specified in section 4, excepting paragraphs 4(2)(a) and (b), must be followed. Sampling is not required within areas of the tenure or 1 g C/m^2/day depositional contour where depths exceed 300 m.

(2) Specifically for Quebec, Nova Scotia, New Brunswick, or Prince Edward Island, Table 1 is used to determine the number of sediment samples at 0 m stations and transects.

Exception

(3) Sediment grain size is not required to be measured during operational monitoring.

Visual Monitoring [AAR paragraph 11(2) (a)(b) and (c)]

11. (1) The procedures in subsection 5 will support compliance with the facility restocking threshold.

(2) In the case of an aquaculture facility that is located in tidal waters in or adjacent to Nova Scotia or New Brunswick:

(a) Observations from each transect will be made at 0 m, 10 m, 20 m, 30 m, 40 m and 50 m locations;

(b) The number of transects are indicated in Table 1, Column II based on the number of fish stocked, specified in Table 1, Column I.

(c) Cages along the outside perimeter of the cage configuration must be those selected for positioning of transects. Transects will be positioned starting with the cage with the highest biomass and proceeding in descending order, and in the direction of the prevailing water current;

(d) Compliance stations include all stations between 0 and 50 m.

(3) In the case of an aquaculture facility that is located in tidal waters in or adjacent to Newfoundland and Labrador:

(a) Observations must be recorded along a minimum of 6 transects, consisting of two perpendicular transects from each corner of the containment array and extending away from the array for 100 m with 20 m increments;

(b) Observations from each transect will be made at 0 m, 20 m, 40 m, 60 m, 80 m and 100 m locations;

(c) Additional transects must be recorded from and perpendicular to the middle of each side of an array that consists of more than 9 cages in a row;

(d) Compliance stations include all stations between 0 and 100 m.

(4) In the case of an aquaculture facility that is located in tidal waters in or adjacent to British Columbia, follow subsection 6(3) for sampling locations.

Exception

(5) Sampling is not required within areas of the tenure or 1 g C/m^2/day depositional contour where depths exceed 300 m.

Reference Stations [AAR subsections 10and 11]

12. (1) At least one reference station must be established as required according to the following criteria in the case of an aquaculture facility that is located in tidal waters in or adjacent to British Columbia, Quebec, Nova Scotia, New Brunswick , Newfoundland and Labrador, or Prince Edward Island:

(a) Either consisting of a transect outward from the lease boundary or as discrete stations that are not exposed to biochemical oxygen demanding matter deposited from the facility;

(b) In British Columbia, these are discrete stations between 0.5-2.0 km from the facility location;

(c) The reference station depth is within ± 10 m of the range of depths of the sampling stations as specified in subsection 4(2) and section 6;

(d) Topography, seabed type, current and tidal regimes, sediment grain size, and the amount of freshwater runoff influence are to be representative of the sampling stations, and;

(e) If it is determined that the seabed is composed of predominantly soft sediment, a minimum of one reference station will be established with a minimum of 3 sediment samples collected per station.

(f) If the seabed is determined to be predominantly not soft sediment, visual monitoring must be conducted as specified in section 11.

Recording of Operational Survey Information [AAR subsection 16]

13. (1) Recording of benthic surveys as per section 8.

Exception

(2) BOD modelling, fish and fish habitat surveys and bathymetric mapping is not required for operational monitoring.

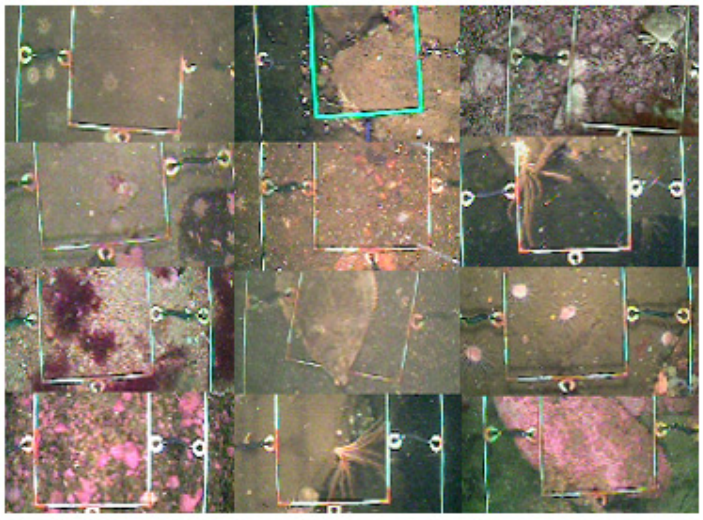
Table 1: Number of Sampling Stations Required for Sediment and Visual Sampling (Nova Scotia and New Brunswick)

Column I	Column II	Column III	Column IV
Maximum number of fish within cage site array during production cycle	**Number of transects**	**Number of sampling stations (not including reference stations)**	**Number of samples (3 samples/station for soft bottom sites at 0 m from containment array)**
1-200,000	**2**	**2**	**6**
200,001-300,000	**3**	**3**	**9**
300,001-400,000	**4**	**4**	**12**
400,001-500,000	**4**	**5**	**15**
500,001-600,000	**4**	**6**	**18**
600,001-700,000	**4**	**7**	**21**
700,001-800,000	**4**	**8**	**24**
800,001-900,000	**4**	**9**	**27**
900,000-1,000,000	**4**	**10**	**30**

Appendix 2

Standard Operating Procedure for Underwater Video Camera System

Standard Operating Procedure (SOP)
for
Underwater Video Camera System



Fisheries and Oceans Canada
Pêches et Océans Canada

This Standard Operating Procedure is designed to aid in the acquisition of underwater benthic video around Newfoundland and Labrador Aquaculture Sites.

If you have further questions please contact the Aquaculture Section, Science Branch, Dept. Fisheries and Oceans Canada, North Atlantic Fisheries Center (NAFC).

This document has been produced by
the
Aquaculture, Animal Health, and
Biotechnology Section, Science Branch,
Dept. Fisheries and Oceans Canada
(DFO),
Newfoundland.

TABLE OF CONTENTS

1.0 INTRODUCTION

In response to the rapidly growing aquaculture industry on the south coast of Newfoundland, Habitat Management (HM) staff of Fisheries and Oceans Canada (DFO) needed to develop standardized monitoring in order to document any changes to benthic fish habitat as a result of these activities. From a regulatory perspective, potential impacts on benthic fish habitat and its biodiversity has typically been monitored by measuring the sulphide content of superficial sediment samples. These sulphide concentrations were then compared to a set of thresholds to determine potential impacts on fish and fish habitat and the need for any regulatory action.

It is important to note that the majority of marine finfish sites in Newfoundland occur over hard bottom substrates rather than soft bottoms so the sediment sulphide approach to benthic environmental monitoring is neither effective nor predictable. Both the sampling technique (grabs) and chemical proxies (redox and sulphide) utilized by DFO in many regions present challenges in areas having hard bottom substrates, which leads to inaccurate and unreliable assessments of benthic impacts. Therefore, underwater video of the benthic habitat was chosen as an alternate means of assessing such impacts.

In order for this methodology to be repeatable and scientifically defensible, it was essential to validate against Newfoundland specific environmental conditions, including the biological assemblages likely to be encountered. Standardizing video collection and data recording and analysis was also necessary for this approach to be successful.

1.1 Purpose:

The main purpose of this Standard Operating Procedure (SOP) is to outline the minimum requirements for collecting high quality underwater video and to standardize data recording and subsequent analysis. This SOP contains a list of the equipment needed as well as step-by-step instructions on conducting underwater video surveys. These procedures will also aid in the setup and deployment of the camera along with the actual processing and evaluation of the video footage.

2.0 SYSTEM DESIGN:

2.1 Equipment

2.1.1 Cage design

A cage is used for underwater camera systems to provide the necessary protection and stability for the equipment tethered to the surface. The cage gives the equipment a platform to rest on while on the bottom, deflects unseen obstacles from the aquaculture sites, and shields the equipment from the benthos while it is being lowered. When designing the cage, ensure the distance of the mounted camera from the bottom of the cage is high enough to capture the external grid, (a 50X50 cm grid used in the lower part of the frames field of view). This distance will maximize the field of view and still maintain an optimal focus distance. As a result of water magnification (25% > than air),

this distance should be checked and modified prior to deployment. Since green or blue colored tape shows up best in the underwater video, it should be used to cover your internal and external grids to maximize contrast, using the internal grid for size reference. Finally, to help prevent snagging or hooking on the bottom, a streamlined cage design should be used.

Cage design should follow specifications presented in Figure 1 and outlined below:

- Cage should be built out of round stock, 1/4" stainless steel material.
- The bottom exterior grid should be 50×50 cm and within the camera's field of view
- The top of the cage should contain mounts for a camera and two lights, which should be oriented towards the centre of the grid (Figure 2)
- Any bolts used should have bolt head covers to avoid snagging (Figure 3)
- The mounting for the lanyard should have a tensile strength of ~1000 lbs (the same rating as the cable), with the eye located at the top of the cage
- The cage needs to have a size reference to be used in the video frame, an internal grid of 25×25 cm located on the bottom of the frame is recommended (Figure 4)
- For size referencing lasers could also be used
- Shiny/reflective material should be kept out of the field of view, as this creates white washout in the video. Any stainless steel should be covered with green or blue tape, as this shows up best in underwater video.
- The camera needs to be orientated down for quantifying and qualifying collected video data

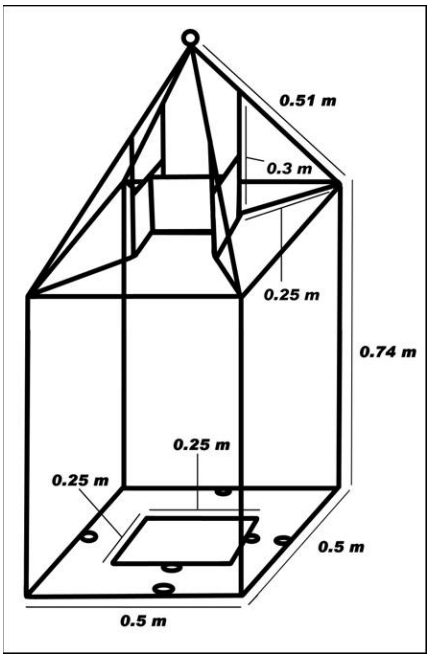


Figure 1: Schematic showing specifications of the camera cage design.

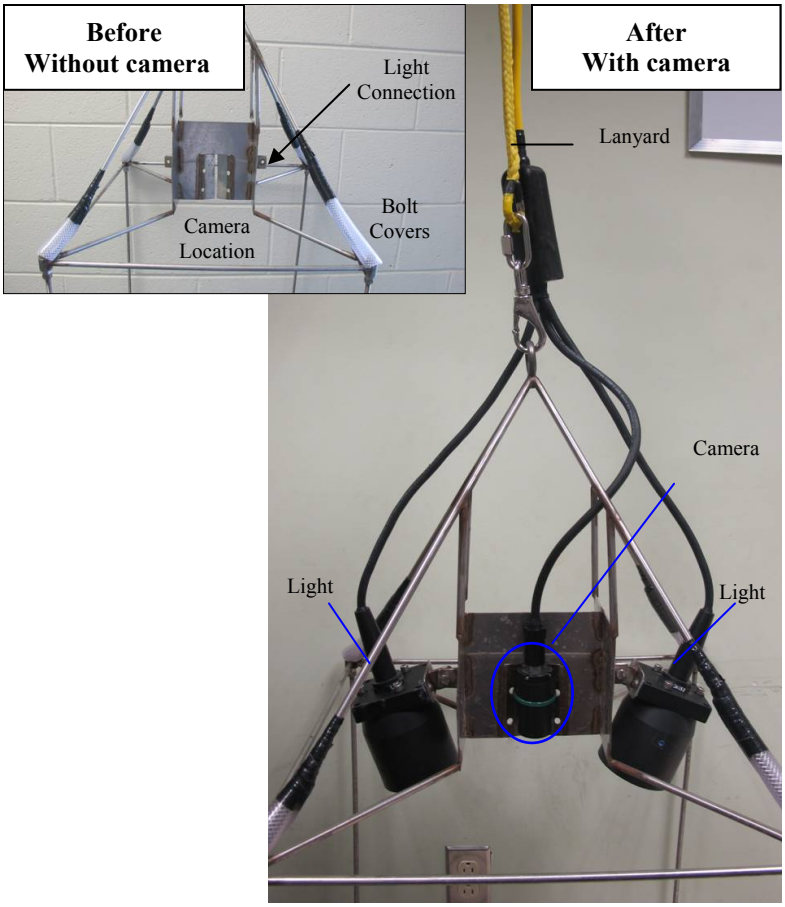


Figure 2: Cage light, camera and Lanyard attachment points (configuration before and after hookup)

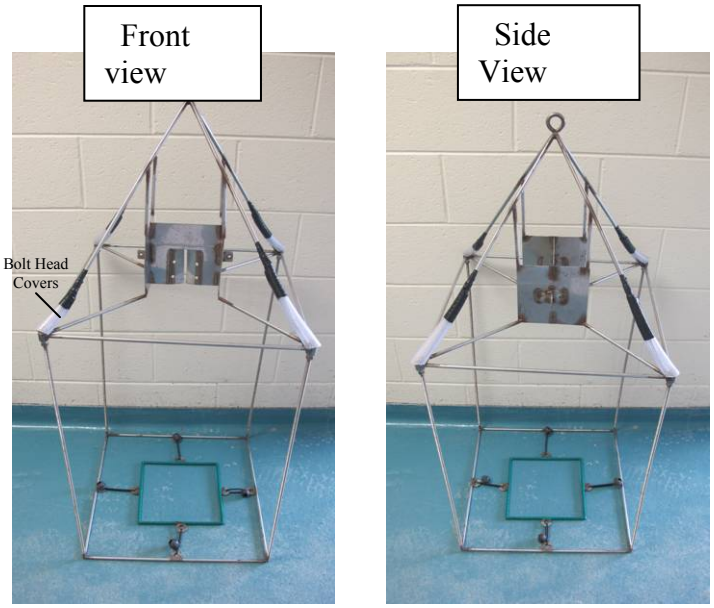


Figure 3: Front and Side view showing the design of the cage for the underwater camera system

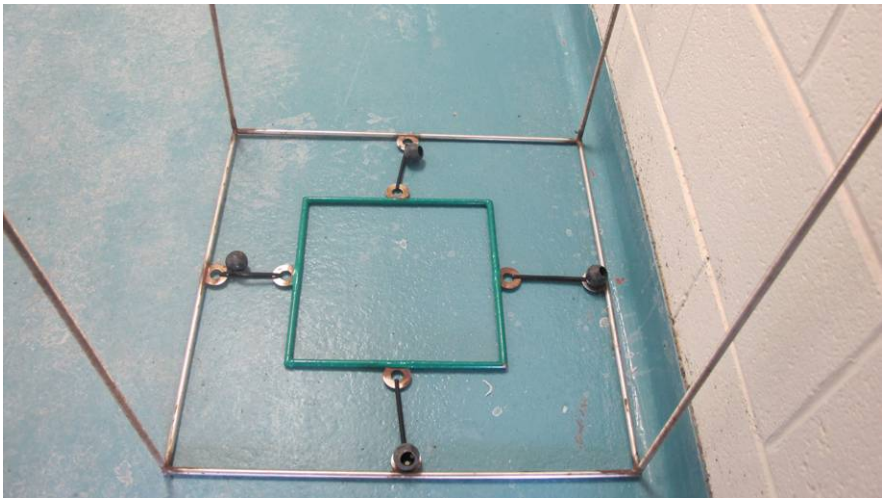


Figure 4: Bottom portion of the cage frame containing the 25x25cm green grid

2.1.2 Camera

The camera used for this set-up needs to have:

- A minimum resolution of 500 TV lines (Experimental camera had 550 TVL)
- A Lux value of 0.05
- A fixed focal length, as auto focus will focus on water particles not the bottom
- For additional specifications of the camera used see Appendix A

2.1.3 Deck Box

The deck box to be used in conjunction with the camera should contain the following:

- A light controller that can adjust the light intensity (Two 150watt lights; Appendix B).
- A power distribution box, which is usually included with the light control (Appendix C)
- A Global Positioning System (GPS) and GPS overlay for video
- A screen of sufficient size to allow the user to view video while recording at sea.
  -When using larger monitors the user needs to take into account sunlight and water resistance
- A recorder, in digital format, to help speed up the processing (Appendix D)
  -Some systems can use analog digital tapes, but since video will eventually need to be converted to digital files for submission this is not recommended

2.1.4 Power

A stable power supply, such as a generator, (minimum 1000w and compatible with electronics) is recommended as video quality will be affected by interference or power loss. An extension cord may also be needed to power the camera.

2.1.5 Cable

The cable to provide the video feed should have the following characteristics:

- Have a minimum length of 120m, however, 150m of cable will help account for scope and sounder issues encountered
- Consist of Kevlar-coated copper cable (1000lbs tensile strength)
- Contain dummy plugs
- A container for storage of cable with access hole for connecting to deck box. If the cable will be used for extended periods of time, it is recommended to store outside of the container. When storing the cable, the use of large loops is recommended to avoid kinking or twisting of the cable (min loop diameter is 20cm, loops on the deck should be much larger)

2.1.6 Spare Parts

A System should be designed in components to ensure easy and efficient switch out of broken or defective parts.

- A camera system with modular components is best so switch out of individual items can be done easily and efficiently
- Extra cameras and lights should be available in case some components fail in the field
- One redundant system available for backup (recommended but not required)

2.1.7 Winch system

It is recommended that a winch be used for deployment and retrieval of the camera cage and system. An electric winch (minimum 20cm diameter) worked well, as there is no rope needed, and the cable was used to deploy and retrieve the system. A trap hauler, with a rope, can be used as well; however, this adds an extra variable to the deployment process. The benefit is that there will be no strain on the cable, only the rope, but care is needed to keep both taunt to avoid snagging.

Operation of the winch system will require:

- A boat with working deck
- Two personnel for camera operation
- A sheltered area to keep deck equipment if the camera system is not waterproof. If you are using a waterproof system, a sheltered area is not necessary.

2.2 Additional Equipment

2.2.1 Experimental system

Enhancement and improvements to the system can be achieved through the following:

- Use of a Digital Video Recorder (DVR) instead of digital tapes, videos are in digital format, with analog audio in and out
- Use of a digital coder/decoder (e.g. the Geostamp) to overlay audio with latitude, longitude and time, (data in spreadsheet form recording date, lat, long, and time)

Note: There is a problem with this digital coder/decoder setup: to be most efficient you will need proper software developed to include, depth, species and substrate types; with the proper developed software processing time will be significantly reduced.

- GPS splitter wire to overlay coordinates on video
- A depth recorder to link depth at every station to the database. As there are discrepancies between the boat sounder and actual cage depth, due to sudden bathymetry changes, it is recommended that a logger be attached to the cage frame
- Depth loggers can be used to compensate for errors in the sounder at certain locations (ensure that the time is synchronized with the data overlay on the video)
- Additional data collected by the depth loggers, such as temperature, can help with species identification

2.2.2 Future system possibilities/upgrades

- Use of LYNN real time video enhancement
- Installation of a slip ring for cable
- Use of a zoom lens for the camera, useful for identification of some species
- Installation of lasers for size reference
- Installation of a device for measuring the deposition depth (e.g.: grid attachment)
- Attachment of additional sensors, such as a dissolved oxygen probe

3.0 OPERATION

3.1 Camera Operation

3.1.1 Experimental Setup

The following procedure should be performed for experimental set-up:

1. All components associated with water should be inspected and the cable connections greased properly using a light skim of silicone grease, just enough to cause the rubber to shine
2. Attach the lanyard to cage frame making sure there is enough slack at the camera and light connectors to prevent strain (Figure 2)
3. Attach the camera lens to the frame using cable ties. This may need slight adjustment to line up the video grid properly. The use of rubber backing will help keep the camera in position
4. Attach both lights to the frame housing, ensuring that the lights are **turned off** out of water as the plastic casing will overheat and melt. Lights should be attached totally within the frame to avoid potential snagging
5. Angle lights to hit the middle of 25×25 cm internal grid

3.1.2 Experimental deck box configuration

The deck box configuration should follow the schematic presented in Figure 5 and colors mentioned in text are specific to this figure. Set-up using the steps outlined below:

1. Attach camera/light cable to main deck box (yellow wire).
2. Attach video out from deck box to DVR (red RCA wire).
3. DVR video out connected to external monitor (blue S-video).
4. Attach GPS to both the deck box (pc connector) and GEOstamp, (Digital coder/decoder), via serial port, (if available). If no GEOstamp is being used, then only one connection to deck box is necessary (green/purple wire).
5. Ensure GPS antenna is in clear location to get satellite signals; fiberglass or thin plastic is not an issue in picking up satellite signals.
6. The Digital coder/decoder audio out should then be connected to the DVR via audio in (audio out on the GEOstamp, red RCA connector).
7. Connect power to DVR, deck box, monitor and Digital coder/decoder from 1000w generator and power bar (black wire).
8. Once everything is connected, test video and GPS overlay. The field of view should be seen on the monitor along with the GPS position (if outside). Adjustment of the lens will be needed in the frame to ensure frame alignment (external grid must be seen in the field of view and it should be relatively square). Actual position of camera on the frame must be preset to show the frame underwater, as water has a magnification of 25%.
9. Once all components are working and video overlay is seen on the screen then sampling can start.
10. Lights for the camera system can be turned on once the cage is put in the water. For best results when using 150w, the highest setting of 100% produces the best image at depth. It should be noted that light adjustment may be necessary under certain conditions (i.e. at shallower depths the image may become washed out with light reflection and a reduction in light intensity may be needed). Finally, ensure the lights are off before cage is removed from water to avoid over heating.

3.1.3 Additional Notes

The system used here is not waterproof. Newer systems can be purchased that are compact and waterproof or water resistant.

It should be noted here that video systems can be purchased to include all these components in one deck box with all wiring hidden and water resistant (the present experimental system was designed to test components). It is important to ensure the cage design, camera setup/specifications and deck box specifications meet the minimum requirements for high quality video.

The DVR setup is specific to the type of recording device used. This system required using the analog video setup in which the video would be recorded by just pressing the record button (see DVR manual for specifications). This unit worked best when recording

was started and put on pause throughout survey site. If purchasing other DVR systems it is very important to insure resolution of recording meets or exceeds the camera resolution, video quality should be due to the camera NOT the recording format.

It is a good practice to secure the cable end to the boat to avoid potential pulling of the connections and to decrease chances of cage/cable loss over the side of boat.

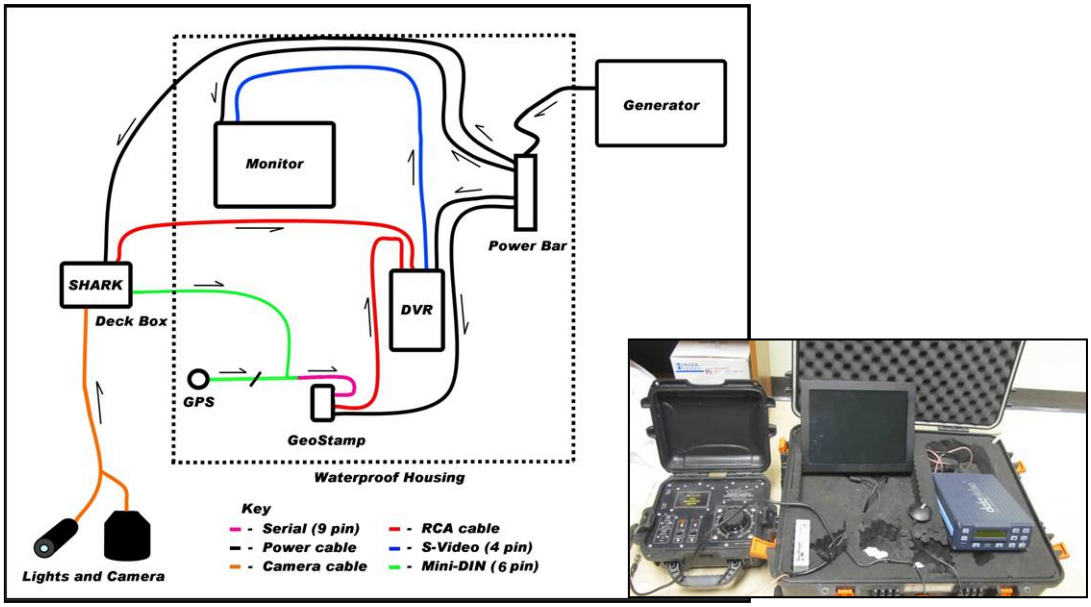


Figure 5: Deck box, monitor and DVR configuration (picture of actual deck box without light/ camera and generator connection)

4.0 VIDEO RECORDING

4.1 General/Typical Recording

For best results one person should operate the cable and observe the monitor. In some cases two people may be required (i.e. if the monitor is not next to the winch). In such circumstances communication protocols would have to be properly established (i.e. raising/lowering, spin left/right, etc).

Once camera is on or near the bottom and cable is perpendicular (i.e. straight down with 0^0 scope) underwater video recording should begin using the following procedure:

1. Start recording video as the bottom comes into focus.
2. The date/time(GMT)/lat/long/depth should be recorded for each drop in a field notebook.
3. Randomly place camera cage gently on the bottom at a site for ~10 sec, to insure a clear image for video analysis (see Figure 6 for sample clear image), then raise cage ~ 30 cm and drop to confirm benthic substrate type.

4. If camera is zoom capable then the zoom function should be completed after the 10 sec rule and before the drop, and the camera should return to the original position before confirmation of substrate type.
5. The number of recordings per station are subject to the resolution necessary for analysis, if more are required move cage slightly on bottom and repeat, complete the 30 cm drop for substrate type at the end of the station, not after each image because it will reduce water clarity (ensure that grids do not overlap).
6. Once water is clear, pause the video and either remove the camera (i.e bring the camera to surface), or raise it to a safe level above the bottom for travel until you reach the next station.
7. Once camera is at the next station repeat steps 1-6.

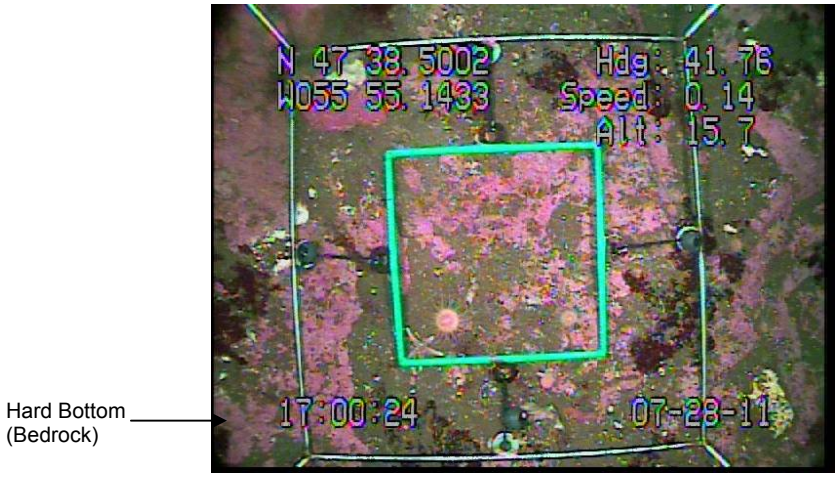


Figure 6: Camera in Position on the Bottom for ~ 10 sec. Substrate in this Picture is Bedrock

4.2 Vertical Rock Wall recording (Exception to typical recording procedure)

Sometimes video capture of the bottom at a site can be difficult due to a vertical rock face, whereby the camera cage cannot sit directly on the bottom to obtain the grid image. In such cases, a side profile of the rock surface (Figure 7) would need to be captured following the procedures outlined below:

1. Once the side of the cage comes in contact with the rock wall consider that the bottom, if there is no visible substrate below
2. The user can try to drop the cage 1-2 m more in order to obtain more coverage, but should exercise caution to prevent tangling the cage and cable
3. Treat the station the same as the above video for bottom sampling (Steps 1-6)
4. Retrieve camera, either to the surface or location above rock wall

Figure 7: Camera in Position on a Rock Wall

Note: It is easier to carry out the above sampling procedures if the boat is tethered to a cage or stationary buoy as the operator can hold position with minimal effort. Generally, all camera work is easier if the boat is fixed in a stationary position or on one plane (i.e. tied to the cage at a set distance). The operator is then only concerned with sideways motion, not front and back.

5.0 SAMPLING METHODS

This section describes the way videos should be taken at each station and how to move from station to station. Ultimately, video at each station should be completed in the same consistent manner as stated in Section 4.1.

Video sampling at a particular location can fall into two categories depending on whether there are any underwater obstructions at a site. If conducting baseline surveys and there are no known underwater obstructions such as mooring ropes and grid lines, then drift lines with the camera can be performed. *(1) Drift line* sampling permits the camera operator to raise the camera just off the bottom and move from station to station, thereby eliminating the need to bring the camera aboard the boat after each drop point. If there are cages on a site or if the site is in fallow with a lot of the underwater infrastructure still in place then (2) *Drop sampling* should be performed. This is similar to drift line sampling; however, the camera is brought to the surface after each drop before moving to the next location. It should be noted that boat operation is critical for the drop sampling procedure. If you can tether to a cage or mooring float and move out in graduated increments, the operator needs only to worry about one directional plane making it much easier to complete both drift and drop video sampling.

5.1 Drift line procedures

1. Record date, station number and site at the beginning of the drift line (in field book and white board display at beginning of video).
2. For the first station the video camera is deployed to the bottom and the video is recorded following procedures in Section 4.1 (i.e. drop the camera cage gently on the bottom at a site for ~10 sec and raise the cage approximately 30 cm and drop it to confirm the benthic type).
3. Wait until water clears before pausing video.
4. Raise the camera to a safe distance off the bottom, usually until the bottom is no longer visible and proceed with the boat to the next station (Figure 8).
5. Once at the next station and the cable has 0^0 scope (i.e. cable is perpendicular to the water) lower the camera to the bottom and start recording again, follow procedures outlined in Section 4.1

5.1.1 Advantages

- Site can be completed relatively quickly, as time spent retrieving and deploying the camera is reduced.
- No extra hauling, with minimal use of winch.
- No extra rope is required as everything is controlled from the cable.

5.1.2 Disadvantages

- Greater chance of hooking bottom or unknown obstructions.
- No individual station coding used, so stations must go by time stamp on video.
- More difficult to obtain still images as the boat may be moving too fast and the yellow cable will not be perpendicular to the water surface.

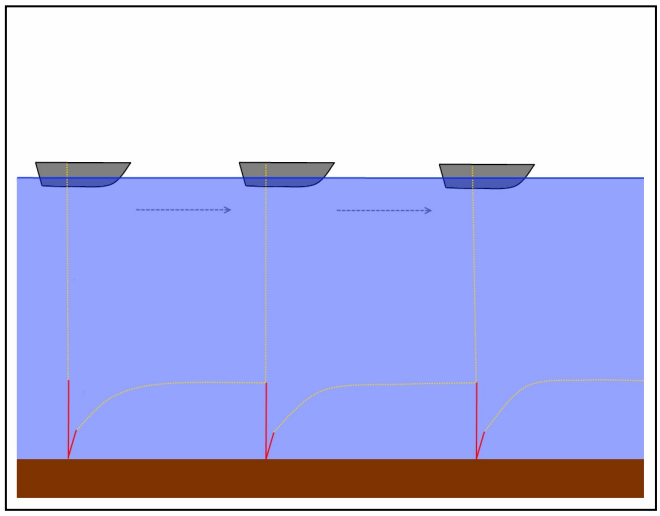


Figure 8: Drift Line Procedure for underwater video, recording only at each station (see red drops).

5.2 Drop sample Procedure

1. Record station position and site location on white board. Video camera to be deployed to the bottom and retrieved to the surface to avoid underwater obstructions such as ropes and mooring lines.
2. Attach a rope to cage, if available, to aid in camera retrieval via winch system (easier for multiple drops at a site). It is better to use the electric winch and only the yellow cable, one cable/rope to worry about (Figure 9).
3. Control of camera should be with the cable, not rope (keep rope taunt and only use to retrieve camera).
4. Camera operator should control the cage with the cable and monitor viewing screen.
5. Record as bottom comes into view, randomly drop camera cage gently on the bottom at a site for a ~10 sec and raise cage ~ 30 cm and drop to confirm benthic type (see section 4.1).
6. Wait until water clears before retrieving.
7. Return cage to surface, move to new station, mark on white board and repeat.

5.2.1 Advantages

- Stations are more organized as they are visually labeled.
- Reduces the chances of snagging on underwater obstructions.

5.2.2 Disadvantages

- Winch and extra line may be needed, which is a two man operation; one person to control winch and another to control camera and its applications.
- may move off station in the time it takes for camera to reach bottom
- More labor intensive and time consuming.

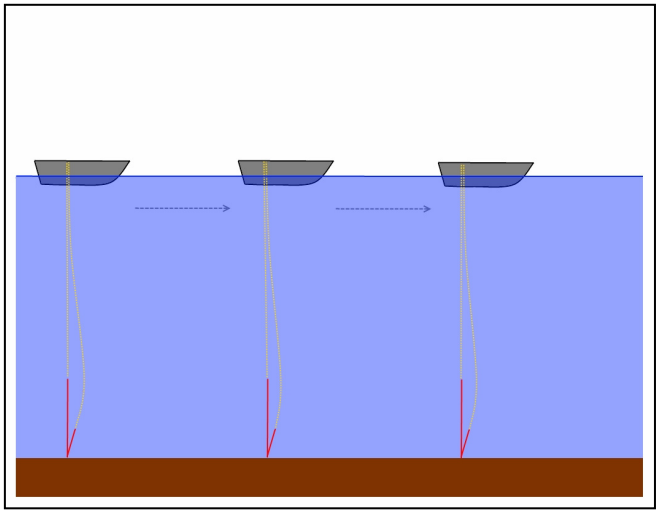


Figure 9: Drop Sample Procedure for underwater video; recording only at each station and camera retrieved each time (see red drops).

6.0 DISASSEMBLING/CLEANING SYSTEM

Once video survey is complete, the camera system needs to be cleaned, disinfected and packed away. This is especially important if you plan to visit other sites in the near future, as all equipment including ropes must be cleaned and disinfected for bio-security purposes. Iodine-based products, such as Wescodyne, are recommended as they work well around salt water. For best disinfection, equipment should be cleaned and then dried thoroughly. Once the bio-security issue has been addressed the basic steps needed for the care of your equipment are as follows:

1. Ensure connections are dry and rinse all components exposed to salt water with fresh water.
2. Take care to coil the cable in a plastic container, ensuring there are no kinks. A good rule of thumb is to turn the cable over and under, taking care not to force it, as the cable cannot be treated like rope. The use of a slip ring would solve this problem.
3. Rinse the Kevlar cable with freshwater as well.
4. The system should be stored in a clean, dry place.
5. Disconnect any stainless steel to avoid electrolysis.
6. Backup video as soon as possible.

7.0 VIDEO PROCESSING

When processing the video, follow three major steps to ensure the highest quality end product is obtained that can be easily utilized and presented to the DFO-HM staff.

7.1 Video Observation

1. Convert digital video to highest resolution format (eg. avi or equivalent).
2. Visually scan video for substrate type and any species observed.
3. “Image Capture” (freeware) can be used to analyze video and capture pictures if necessary. Refer to the help section of this software for methodology.
4. If pictures were taken, then representative substrate for the station needs to be captured usually when the camera is stopped for ~10 sec.
5. For key species that need to be quantified and are too numerous to count (e.g. Beggiatoa) the grid or laser tool should be used to determine the percent coverage in the 50x50 cm external grid).

7.2 Documentation

1. Free software such as "Image J" can help in determining the percent coverage within a specified area. However, it is important to keep in mind that a realistic resolution of the coverage is around +/-10% and "image J" will calculate to at least 1% (this requires a still image/picture). See the help section of this software for methodology.

2. Record species to lowest taxonomic level possible (e.g. class, order, family, genus, species) keeping in mind that with this type of analysis species identification may not be possible without "ground truthing" (i.e. species capture).
3. Quantify species present in the 50cm×50cm grid, (if different species fall out of the grid make note and record in the comments section of table in Appendix E).
4. Record all data on spreadsheet in the format seen in Table 1 (Appendix E1).
5. The table format (Appendix E1) will be consistent among users until the Fauna species are listed. This section of the table will vary from site to site.
6. Temperature and actual depth can be recorded with a small data logger, which can be time synchronized with the video; example of the data recorded at a site is provided in Figure 10.
7. If necessary, data can be easily grouped for additional statistics.
8. Follow the key provided with Table 1 (Appendix E2), which explains each individual column.
9. A standardized table following the same format presented here will ensure quality and consistency when processing the video.

Note: Recording can be done manually or digitally using coding software and the digital coder/decoder (this software is not fully developed as of yet).

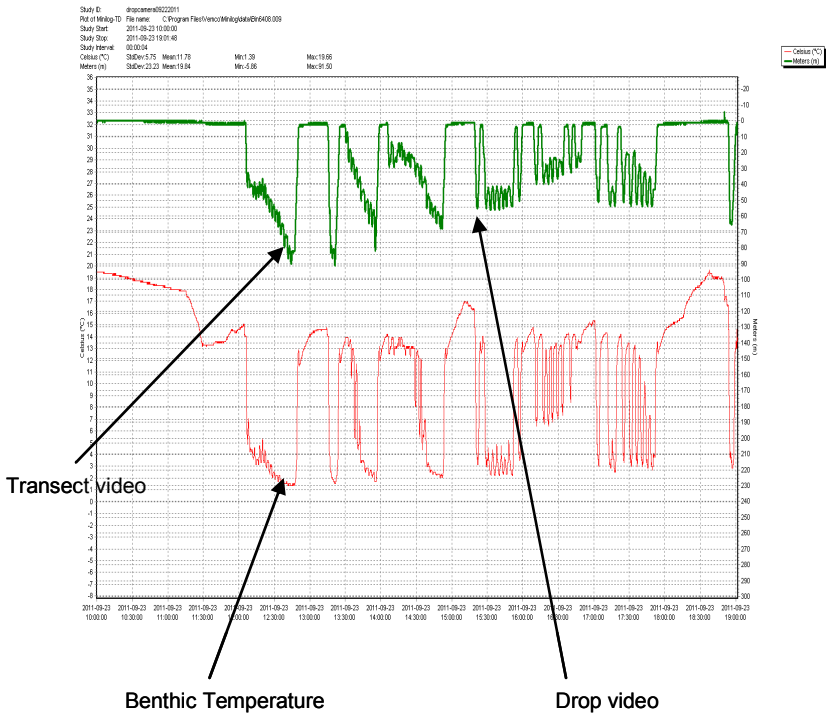


Figure 10: Depth and Temperature Recording at One Particular Site, Both Drift video and Drop Sample can be seen (data can be exported in ASCII as well)

7.3 Final Reporting

The final report should consist of a table identical to Table 1 in Appendix E, with the above parameters as well as a statistical summary of what was found on the site and at each station. A DVD copy of the video would also accompany the report. If any species of interest were observed they would be easily found on the recording via the time stamp, therefore validation and post-processing of the data can be easily performed.

APPENDIX A: Camera Specifications

SV-16HR Colour Underwater Camera

Specifications Sheet

Rev. 2011-09-30

SV-16HR Specifications

SV-16HR Specifications	
Pickup Device:	Sony Super HAD CCD
Picture Elements:	810(H) x 508(V)
Scanning System:	2:1 Interlace
Scanning Frequency:	NTSC: 15.734 KHz(H), 59.94 Hz(V) PAL : 15.625 KHz(H), 50 Hz(V)
Resolution:	550 TVL
Angle of View:	92 degrees
Minimum Illumination:	0.05 Lux / Faceplate
Video Output:	1.0 Vp-p Composite (75 Ω)
Lens:	3.6mm fixed
Power Requirements:	DC12V (+/- 1.5VDC)
Power Consumption:	110 mA
Dimensions:	7.4cm x 3.8cm dia. (3" x 1.5" dia.)
Weight:	136 grams (.3 lbs)
Depth:	600 m (2000 ft)

*Specifications subject to change without notice.

APPENDIX B: Light Specifications

SV-Q10K Underwater Light

Specification Sheet

Rev. 2011-09-28

SV-Q10K Underwater Light Specifications:

SV-Q10K Specifications	
Length:	12.8 cm/ 5 inches
Width:	9 cm/ 3.5 inches
Height:	9 cm/ 3.5 inches
Weight:	758 g/ 26.7 oz
Depth Rated:	3000 m/ 10 000 ft
Lamp Style:	Mini Candelabra Base
Lamp Voltage:	120 or 240 Vac
Lamp Wattage:	100, 150, 250, 500 Watts
Bulb Life:	+2000 hours
	*Specifications subject to change without notice.

APPENDIX C: Power Distribution/Light Control

SV-VLC1 Video Light Console

Specifications Sheet

Rev. 2011-10-03

SV-VLC1 Specifications

SV-VLC1 Video Light Console Specifications	
Power In:	120 VAC @ 5 amp Max (optional 240 VAC)
Camera Power:	12 VDC @ 1.7 amp
Light Power:	120 VAC Full/Half power
Dimensions:	12.5"x10.1"x6.0" (315x225x150 mm)
Case:	905 Nanuk
Video Output:	Composite, 75 Ohm Unbalanced
Video Loop-through:	Yes, Video In
Operation Conditions	5-50 C (41-122 F)
Additional Options:	
Variable Light Control	Variable Control replaces light hi/lo switch
GPS Overlay	Displays location on video – GPS Included
Text Overlay	Allows text to be entered – Keyboard Included
Lynn Overlay	Adjustable enhancement of display quality

*Specifications subject to change without notice.

APPENDIX D: Recorder (discontinued)

DN-300 DV/HDV Hard Drive Recorder

An instant on, "drag-and-drop" DV/HDV hard drive recorder. Accepts digital or analog video inputs, DV and HDV (through Firewire), component (YUV), S-Video (Y/C) and composite (CVBS) analog inputs. Every DN-300 includes a 250GB hard drive for over 19 hours of video. The Datavideo DN-300 reduce the cost of tape, with continuous recording of up to 18 hours without tape.
After recording simply connect the DN-300 to a computer based editing system via firewire and start editing immediately.

VTR-style controls with large, illuminated buttons and a two-line backlit LCD display let the user select play, rewind, fast forward, fast reverse, pause, frame advance, file selection, file delete and loop play.

Other features include seamless repeat loop play (for trade shows), variable speed forward or reverse play and frame by frame playback in forward and reverse.

Features

- Standalone DV/HDV hard drive recorder/player
- 250 GB hard disk drive – record more than 18 hours
- Records DV from either digital or analog inputs via component, composite S-Video or Firewire
- Records HDV from HDV input via FireWire
- Records direct to a native video format including HDV (.m2t) & DV (.dv) while monitoring on an Analog source
- Can record and playback up to 99 tracks
- Support DV time code
- Full VTR playback functionality, including seamless looping
- VTR-style buttons make it easy to use and navigate
- Variable-speed playback, forward and reverse
- Drag and drop file transfer to PC or Mac via FireWire
- DV video saved as .dv files, HDV video saved as .m2t files
- Converts to .AVI with the push of a button
- With the included PC CD software, you can convert to many other formats: Quicktime, AVI Type 1 and 2, Sony ES-3 Canopus AVI Type 1 and 2, Sony DSR DU-1 DV (.dvd), Matrix RT2500 DV, Avid OMF DV, .dif, .dvsd. The CD Software allows you to batch the file conversion (see below).

APPENDIX E:
Association Field Sheets
The following appendix contains the field sheets that need to be completed as part of the Standard Operating Procedure.
Appendix E1 is a template for recording field observations and video analysis (Table 1.0).
Appendix E2 is a key to Table 1.0 parameters presented in Appendix E1.

APPENDIX E1: Table 1.0 Field observations and video analysis template

Site: _____

Date:_____

General Information										Substrate								Indicators							Flora		Fauna		
Station ID	Cage # (starting)	Transect (m)	Time (GMT)	Latitude (dd.mm)	Longitude (dd.mm)	Depth (m)	Temperature (°C)	Video (Clarity 1-5)	Photo #	Primary Substrate (H/S)	Rock Wall	Bedrock	Boulder	Cobble	Gravel	Sand	Silt/mud	Flocculent	*Beggiatoa* (%)	OPC (type)	OPC (%)	Off Gassing (Y/N)	Feed (Y/N)	Shells (Y/N)	Sediment Color	Coralline Algae (%)	Kelp (%)	Species 1 (#)	Species 2 (#)	Comments

APPENDIX E2: Key for parameters presented in Table 1.0 of Appendix E1

General notes:
For total analysis view all video for that station
Analyze video and then select the photo that best represents the station ... keep video quality and camera cage position into account
Try to capture the photo for each station based on the substrate and indicators
For Fauna, analysis video record species seen in column header and build on the table as you process the video
For Flora use the 50cm by 50 cm grid for analysis to get % cover
For % cover use the grid and image J whenever possible (should correspond with the photo whenever possible)
The comments should include any relevant info or changes noted

Site:	**General location**	
Date:	**dd/mm/yyyy**	keep date in this format for consistency

TABLE COLUMN HEADER KEY

STATION ID	**X.X**		sequential order: may be recorded on white board or may have to use time stamp for drift transects (Note: the last digit would change sequentially for repeated stations)
CAGE # (starting)	**X**		gives orientation of transect line
TRANSECT	**M**		usually in meters from cage edge
TIME	**gmt(HH:MM:SS)**		always in GMT, for consistency and time sync(24hour clock)
LATITUDE	**dd.mm**		degrees, decimal minutes from photo
LONGITUDE	**dd.mm**		degrees, decimal minutes from photo
DEPTH	**M**		actual depth when camera touches bottom, may be from boat... better if from data logger
TEMPERATURE	**^{0}C**		if collected, this is the temperature at the bottom
VIDEO CLARITY	**1-5**		1 being poor and 5 being excellent, acceptable quality would be 3 (i.e video can be analysized without quality impeding it)
PHOTO	**#**		the photo and time stamp should be the same, pick photo that best represents the station substrate and indicators
SUBSTRATE	**PRIMARY**	**>50%(hard/soft)**	general characterization of bottom...majority, H for hard and S for soft
	DISCRIPTORS(+/-10%)	**ROCK WALL**	camera positioned along cliff or rock wall and grid can't cover substrate...evaluate by what is present in video frames..., but call it 100% bedrock
		BEDROCK	solid rock in picture
		BOULDER	>25.6cm
		COBBLE	6.4cm to 25cm
		GRAVEL	.02cm to 6.4cm
		SAND	.006cm to .02cm
		SILT/MUD	<.0065cm
		FLOCCULENT	Flocculent material,easily disturbed, can consist of feces and/or soft feed
INDICATORS	**Beggiatoa**	**(%)**	white mat on bottom use 50cmx50cm grid for analysis resolution to +/- 10%
	OPC	**Type**	redish worms in either a clustered colony (C) or dispersed (D) throughout the frame...
		(%)	% coverage of colony or individual worms in 50cmx50cm grid, may be able to group with Image J by color... resolution to +/-10%
	OFF GASSING	**(y/n)**	bubbles seen when cage touches the bottom
	FEED	**(y/n)**	intact feed pellets seen.. May be of various sizes according to site and size of fish
	SHELLS	**(y/n)**	mostly mussel shells that have been cleaned off the cage
KEY SPECIES	**SEDIMENT COLOR**	**Normal/black**	focus on presence of black sediment, anything else would be considered normal
	FLORA (%)	**Coraline Algae**	coralline algae, usually reddish pink covering the rocks use 50cmX50cm grid for analysis
		Kelp	wide variety of kelps, use 50cmX50cm grid for analysus, consider percent cover for all even the hold fast types.... Record what you think it is in comments
	FAUNA (#)	**Species #1**	replace Species #1 with species seen, common names are fine as long as they are identified to lowest taxa possible: record total number seen IN the grid
		Species #2	next species seen, record same as above
		Species #3	next species seen, record same as above
		Species #...etc	keep adding species according to what is seen on video (each site will differ in this area)
COMMENTS			this column is decicated to other relevant information... record species that you think are in the flora fauna section

NOTE:
Typically table with be consistant from Date to Flora for each site
Fauna will be listed according to appearance for each site, therefore will vary from site to site
KEY is to record number seen in the grid when video is stationary for set period