

Nova Scotia Aquaculture Environmental Monitoring Program

For the first time, a comprehensive Environmental Monitoring Program (EMP) is being carried out for the marine aquaculture industry in Nova Scotia. Due to industry expansion, increased public concern and a commitment to ensure environmental sustainability, the Nova Scotia Department of Fisheries and Aquaculture (DFA) implemented an EMP in the fall of 2003. With over 330 marine aquaculture sites throughout many coastal ecosystems, with large and small growers culturing a variety of species, the need for an adaptive province-wide monitoring program was clear.

The Aquaculture Association of Nova Scotia developed a protocol for DFA to implement. One of the first duties was to refine the sampling protocol to reflect the latest scientific thinking, allowing for both practical and effective methods of assessing



potential environmental impacts. DFA engaged some of the best experts, many of whom are from Nova Scotia (Bedford Institute of Oceanography and Dalhousie University) to create a program that would work effectively and be scientifically defensible over the long term.



On an ongoing basis DFA consults with the Nova Scotia Aquaculture Environmental Coordinating Committee and manages the EMP with its regulatory partners. The EMP also benefits from the assistance of other areas within the Department of Agriculture and DFA, including the Regional Fisheries Representatives, Aquaculture Fish Health Unit, Inland Fisheries Division, and Fisheries Inspection staff.

Sampling Methodology

Using the most current sampling techniques, monitoring is conducted on both aquaculture leases and at reference stations in the bay. Monitoring consists of collecting qualitative (video) and quantitative (sediment and water analysis) data from coastal areas throughout Nova Scotia. The EMP focuses on the potential effect of aquaculture on bottom sediment rather than the water column. Effects of aquaculture on marine ecosystems tend to be more concentrated and persistent in bottom

sediment compared to the water column, which is regularly flushed by tides and currents. Sediment samples also tend to provide a more accurate and constant assessment of environmental change.

The EMP follows a risk-based approach that recognizes increased risk requires increased monitoring. All sites currently in production are tested and those with larger production are given higher priority. Sites of potential concern are subject to repeat sampling and, if required, remediation action is implemented.

Environmental Quality Definitions

Through scientific research, Environmental Quality Definitions (EQD's) have been established as a means of classifying the level of environmental change in marine sediments (see Table 1). The EQD's contain both qualitative and quantitative variables. For regulatory purposes, the focus is on sediment geochemistry. Analysis of marine sediment for this program is based on the measurement of sulphide, redox, organic content and porosity:

Total dissolved *Sulphide* is a measure of the accumulation of soluble sulfides, a major product of sulfate reduction that occurs under anaerobic conditions. It is a sensitive indicator of habitat degradation due to organic loading and the main parameter currently used to determine direct impact of an aquaculture operation.

Redox is a measure of the oxidation-reduction potential in sediments. It is also an indirect indicator of aerobic versus anaerobic conditions. This measure is often used to support the sulphide findings.

Organic content is the proportion of sediment that is of plant or animal origin (combined). This variable is a good measure of organic loading on a particular aquaculture site and can be compared to reference stations nearby.

Porosity is the percentage of pore volume or void space, or that volume within any material (e.g. bottom sediment) that can contain water. Porosity is also known as sediment water content and can be used to interpret recent deposition at the sediment surface.



Table 1: Environmental Quality Definitions for Nova Scotia Marine Aquaculture Monitoring

	Measurement	Norm-oxic	Sub-oxic	Anoxic
Qualitative Measures (from video & sediment observations)	Sediment colour	Tan to depth of > 0.5 cm	Tan to < 0.5 cm and/or patchy black sediments at surface	Surface sediments black
	Microbial and algal (plant) presence	No sulfur bacteria present (also benthic microalgae or macro-algae at shallow sites)	Patchy or occasional sulfur bacteria and cyanobacterial biofilms	Sulfur bacteria may be widespread
	Macrofaunal (animal) Assemblage	Wide array of infauna and epifauna; may include large burrowers	Mixed assemblages of small infauna which may include larger animals	Small infauna or tube-dwellers at shallow sediment depths
Quantitative Measures (from sediment analysis)	Redox (mV)	0 to 300	-100 to 0	< -100
	Sulfide (µM)	< 1300	1300 to 6000	> 6000
	Organic content (%)	≤ reference*	1.5 - 2X reference	> 2X reference
	Porosity (%)	≤ reference*	1 to 10X reference	> 10X reference
Site Classification		Type A	Type B	Type C

**Values compared to reference assume that reference and lease stations would have had similar levels in pre-culture conditions.*

Modified from the Design of the Environmental Monitoring Program for the Marine Aquaculture Industry in Nova Scotia, 2002, by J. Smith, J. Grant & R. Stuart



Results

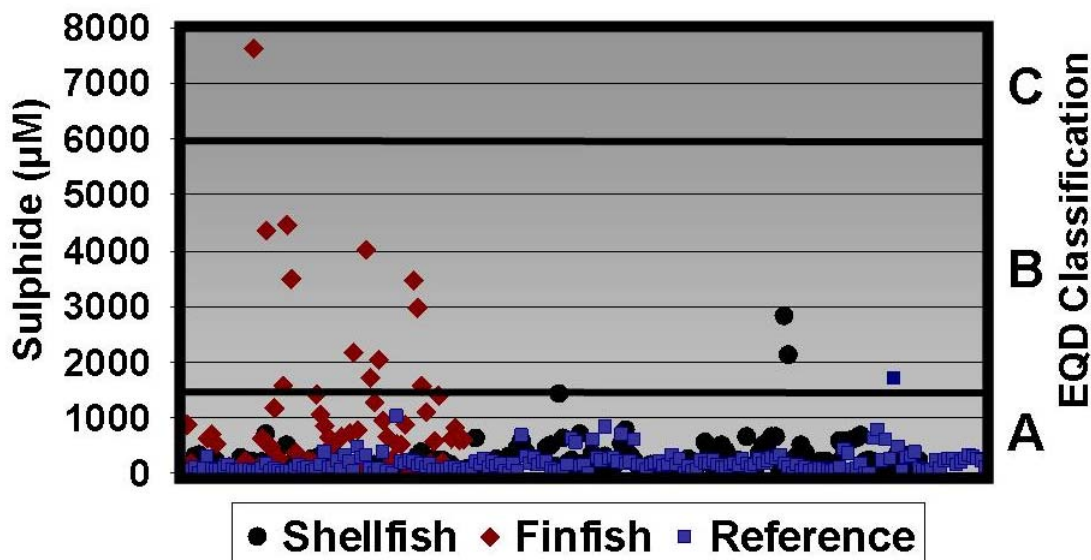
By the end of 2005, the EMP had collected over 1300 sediment samples from 461 stations in 39 different bays. This includes 67 stations at 36 finfish sites (mostly salmon and steelhead) and 183 stations at 123 shellfish sites (mostly mussels). In addition, 211 reference stations were sampled as a comparison to pre-culture conditions and to assess any bay-scale effects. Over 85% of marine aquaculture sites have been sampled, including all active sites. Province-wide sampling continued in 2006 and the results will be compiled, analyzed and made available over the winter. The program is well on the way to exceeding its targets of completing the baseline sampling of all aquaculture sites by the end of 2007. A map of the bays the EMP has sampled is presented below.



Monitoring between 2003 and 2005 formed a baseline of current environmental conditions related to aquaculture development in Nova Scotia. As the baseline data is collected and ranked throughout the EQD classification scheme, the level of risk associated with each operation to the marine environment quickly becomes obvious.

Figure 2 shows the mean sulphide concentration at all stations sampled from 2003 to 2005 in relation to the EQD table. The vast majority of sites are within the norm-oxic, or “A” classification. There are a small number of stations within the sub-oxic, or “B”, classification and those occur mostly within a handful of finfish sites. Only one station was within the “C” range. The Province, in conjunction with its regulatory partner (DFO) and the site operator, has implemented a site remediation plan to improve the sediment conditions within portions of that site.

Figure 2: Mean Sulphide by Sampling Station – 2003 to 2005



baseline data set DFA can now assess risk between variables (e.g. finfish vs shellfish, bay vs site, active site vs non-active site).

The EMP is recognized as an innovative and effective program by other jurisdictions. The EMP is one of the few marine monitoring programs that employ similar methods to sample a diverse aquaculture sector that includes

both big and small finfish and shellfish operations located in a variety of marine ecosystems. It is also the first time that such a program has been carried out in Nova Scotia and is the first time



that empirical evidence exists on an industry-wide scale. The growing body of data that has been collected will go a long way to ensure that aquaculture in Nova Scotia remains environmentally sustainable.

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Fisheries and Aquaculture