

# BEST MANAGEMENT PRACTICES FOR SUSTAINABLE AQUACULTURE IN ONTARIO

## STANDARD OPERATING PROCEDURES

These Standard Operating Procedures (SOPs) propose minimum requirements for all fish farms. It is prudent, however, for all operators to establish more detailed SOPs in accordance with the specific design and operating parameters of their facility. Where possible, manufacturers' monitoring and maintenance schedules for equipment and systems should be incorporated. The SOPs should be compiled in a written format that can be used for both scheduling and documentation purposes.

### STANDARD OPERATING PROCEDURES ENVIRONMENTAL INTEGRATION: LAND-BASED OPERATIONS

#### Effluent Management Procedures - Current

In Ontario, minimum treatment is required for effluents from aquaculture facilities, typically entailing solids removal (e.g. sedimentation, filtration) prior to final discharge into surface waters. Such treatment works are regulated under Section 53 of the *Ontario Water Resources Act* and require a facility to have a **Certificate of Approval** (CofA) for a wastewater treatment system. The CofA usually stipulates operating conditions in accordance with the *Interim Environmental Guidelines for Salmonid Aquaculture Facilities in Ontario*, which recommend the following operational and monitoring practices. Aquaculturists are required to:

- Establish monitoring locations for source water and final effluent discharged to the receiver;
- Collected monthly discrete samples and have them analyzed for total suspended solids (TSS) and total phosphorus (TP) by an accredited (CAEAL) laboratory;
- Design and operate facilities to achieve an effluent concentration equal to or less than 5 mg/L TSS and 0.05 mg/L TP above the levels in the source water supply (compliance criteria are established at 10 mg/L TSS and 0.10 mg/L TP);
- Maintain a log of daily operations and any occurrences that may affect effluent quality;
- Report analytical results to the MOE District Office in accordance with the CofA;
- Report all non-compliant events within two working days of receiving the analytical results and include an explanation of the circumstances and any abatement measures implemented;
- Remove solid wastes from the production units frequently for storage in a lined, non-discharging retention structure that is of sufficient size to store all solids generated during the period of frozen ground conditions;
- Dispose of accumulated wastes by application to cropland at the facility in accordance with the Interim Guidelines or via an alternative, approved method;
- For wastes that are to be removed from the property, ensure that the hauler has a valid Certificate of Approval for an Organic Waste Management System and Site.

## Effluent Management Procedures - Proposed

The effluent monitoring program outlined above represents current requirements under the *Interim Guidelines*. The approach, however, provides only a 'snapshot' of effluent quality at one point in time during the operational day for a facility and is not necessarily indicative of effluent quality. The draft *Wastewater Management and Best Practices of the Aquaculture Sector (BMP)* proposes a revised monitoring strategy based on the collection of time-weighted composite samples of effluent during three seasonal time periods. The revised approach requires that samples be collected during a typical operational day to provide a more accurate reflection of the daily loading from a facility, including wastes generated during routine cleaning and maintenance operations. The revised sampling protocols require aquaculturists to:

- Collect a time-weighted effluent sample at three times during the year - Spring, Summer (during the period of low flow) and Autumn at a sampling station immediately prior to discharge to the receiver as follows:
  - a volume of 250 ml of effluent is to be collected in a clean, twice-rinsed sample jar and placed into a clean sample bucket of at least 3 L in size;
  - the sample bucket is to be kept cool and free of contamination during the day;
  - samples are to be collected every two hours throughout the operational day over a 12-hour period (e.g. 7 samples at 08:00, 10:00, 12:00, 14:00, 16:00, 18:00 and 20:00 hours);
  - at the end of the sampling period, the sample bucket contents is to be mixed and one 500 ml composite sample collected in a clean sample container;
- Collect one 500 ml grab sample of the source water on the same day;
- Collect one 500 ml grab sample of water from the receiver immediately up-stream of the effluent discharge and one 500 ml grab sample of water at a location approximately 100 meters down-stream of the discharge where the effluent is likely to be fully mixed with water in the receiver;
- All four samples are to be submitted to an accredited (CAEAL) laboratory for analysis of TP and TSS;
- Maintain accurate records of daily feed use, water temperature and flow rate
- Estimate the average daily loading of TP and TSS based on the analytical results and operational factors;
- Report effluent concentrations and loadings to MOE within one month of the receipt of analytical results.

## Taking Water Procedures

All facilities that use more than 50,000 litres of water per day from any single source (groundwater or surface water) require a **Permit to Take Water** (PTTW) under Section 34 of the *Ontario Water Resources Act*.

In January 2005, O. Reg. 387/04 Water Taking and Transfer came into effect, specifying that all facilities with a Permit to Take Water be required to:

- measure daily water use with a flow meter or calculate the flow rate using an acceptable and approved method;
- record daily water use in a log; and
- prepare and submit an annual report to the MOE by March 31st of the following year.

These monitoring and reporting requirements will come into effect on January 1, 2007 for all land-based aquaculture facilities. Therefore, prior to that date, facilities using more than 50,000 L/day must install and have operational a flow meter or methodology approved by MOE.

## STANDARD OPERATING PROCEDURES ENVIRONMENTAL INTEGRATION: CAGE CULTURE OPERATIONS

The *Recommendations for Operational Water Quality Monitoring at Cage Culture Aquaculture Operations* (MOE 2001; see Appendix) are the standard monitoring protocols used by the industry at cage culture operations in Ontario. As a condition of the provincial Aquaculture Licence, all cage culture operators are required to undertake environmental monitoring as outlined in the Licence. Monitoring requirements are site-specific to reflect the characteristics and conditions at each site and are outlined in detail in the Licence. As an example, the standard monitoring program requires operators to:

- Establish 3 (facilities attached to shore) or 4 (offshore facilities) monitoring stations at locations 30 m from the cages or the perimeter of the land tenure area and 2 additional reference stations (one up-current and one down-current from the cage site);
- Collect 11 composite water samples at each station as follows:
  - 3 weekly samples during spring turnover,
  - 5 monthly samples during the summer stratification period, and
  - 3 weekly samples during fall turnover;
- Submit all samples to an accredited (CAEAL) laboratory for analysis of total phosphorus (TP) concentration;
- Measure surface water clarity weekly at all stations using the Secchi disc visibility method;

- Measure dissolved oxygen (DO) and temperature profiles at 1 metre increments below the cage site and at all reference stations during the open water season
  - Monitor weekly at Type 1 and Type 2 sites
  - Monitor monthly at Type 3 sites;
- If DO is measured at less than 54% saturation, the frequency of DO monitoring shall increase to \_\_\_\_\_; additionally
  - total ammonia analyses may also be required; and,
  - if reduced DO levels persist, a benthic macroinvertebrate sampling program may be required to determine if impairment of benthic habitat has occurred;
- Prior to the renewal of the Aquaculture Licence for an operation, sediment samples will be collected in duplicate from the reference sites and from two perimeter sites in May and October and submitted to an accredited (CAEAL) laboratory for analysis of TP, total Kjeldahl nitrogen (TKN), total organic carbon (TOC) and particle size;
- Report the results of TP analyses and water clarity during Spring turnover to regulatory agencies within 30 days of the last Spring turnover sample collection;
- Prepare and submit an annual water quality monitoring report to regulatory agencies in accordance with licence conditions;
- Conduct the following, if requested to do so by the regulatory authorities, when median TP results in either the Spring, Autumn or ice-free annual monitoring periods exceed 0.10 mg/L and are significantly different from background levels:
  - an operational audit of feeding and production levels;
  - increased sampling frequency in the subsequent sampling period; and/or
  - assess periphytic algal growth at site perimeter and control sites.

In addition to the requirements of the monitoring programs, aquaculturists will:

- Monitor and record weather conditions (wind, waves, rainfall, storms) and operating procedures (fish transfers, harvesting) that may affect water quality conditions at the facility;
- Maintain records to ensure that monitoring is completed as scheduled and that results are recorded.

## STANDARD OPERATING PROCEDURES INFRASTRUCTURE & CONTAINMENT

To ensure that potential introductions of escaped cultured fish will not present an unacceptable genetic or ecological (e.g. predator-prey relationship) risk to the environment, the Ontario Ministry of Natural Resources (OMNR) requires completion of an acceptable risk analysis prior to approval of licence applications. The required level of facility security depends on the degree of risk that a proposed species poses to the receiving ecosystem. Facility security requirements are intended to mitigate potential impacts. OMNR identifies three classes of aquaculture facilities based on the risk of escape from the facility. A facility that is considered to offer high security for species X may only offer medium security for species Y; therefore, security requirements are established on a species-specific basis and in some cases on a life-stage specific basis. These Guidelines were established through public consultation using the Environmental Bill of Rights process. Three facility security levels are defined:<sup>1</sup>

### 1) F 1 - High Security Facility

A “high security” facility presents the uppermost practical level of security for production facilities. The risk of escape is extremely low. It is recognized, however, that no aquaculture operation can be 100% secure through all pathways at all times.

#### Key Features:

- highly secure source water supplies (ground or treated) OR multiple (3) inflow pathway barriers appropriate to the cultured species and life-stage. At least one inflow barrier must be passive (i.e. not dependent on a power supply);
- AND
- highly secure receiving water/outflow destination (ground, sewage treatment facility, lethal chemical effluent treatment) OR multiple (3) outflow pathway barriers appropriate to the cultured species and life-stage. At least one outflow pathway barrier must be passive (i.e. not dependent on a power supply);
- AND
- highly secure waste conduit (ground, sewage treatment facility, lethal chemical effluent treatment) OR multiple (3) waste conduit pathway barriers appropriate to the cultured species and life-stage. At least one waste conduit pathway barrier must be passive (i.e. not dependent on a power supply);
- AND
- located above regional flood plain, or engineered to contain fish above regional flood plain;
- AND
- one or more methods for controlling access (enclosures such as fencing or building, site location, human monitoring, guard dogs) appropriate to the site.

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<sup>1</sup> Reproduced from Ontario Ministry of Natural Resources Policy – Risk Analysis and Facility Security (FisPp.9.2.5 / August 2004)

## 2) F 2 - Medium Security Facility

In medium security facilities, the probability of live loss is moderate, however numbers are small, usually associated with leakage, as opposed to large loss from catastrophic events such as flooding.

### Key Features:

- multiple (2) inflow pathway barriers appropriate to the cultured species and size but not necessarily able to contain the smallest life-stage at all times. At least one inflow barrier must be passive (i.e. not dependent on a power supply);

AND

- multiple (2) outflow pathway barriers appropriate to the cultured species and size, but not necessarily able to contain the smallest life-stage of the cultured species at all times. At least one outflow pathway barrier must be passive (i.e. not dependent on a power supply);

AND

- multiple (2) waste conduit pathway barriers appropriate to the cultured species and life-stage but not necessarily able to contain the smallest life-stage of the cultured species at all times. At least one waste conduit pathway barrier must be passive (i.e. not dependent on a power supply);

AND

- located above regional flood plain, or engineered to contain fish above regional flood plain.

## 3) F 3 - Low Security Facility

Low security facilities are those which pose a high risk of escapement. Examples include operations connected to Ontario waters, located in a lake or located on a regional flood plain (e.g. earth ponds and floating cages). In low security facilities, losses are inevitable, with potentially large numbers primarily related to storm/seasonal flooding events. Low security facilities are most common where source water is riverine. Regular movement of small fish to and from receiving and/or source water may occur in low security facilities.

### Key Features:

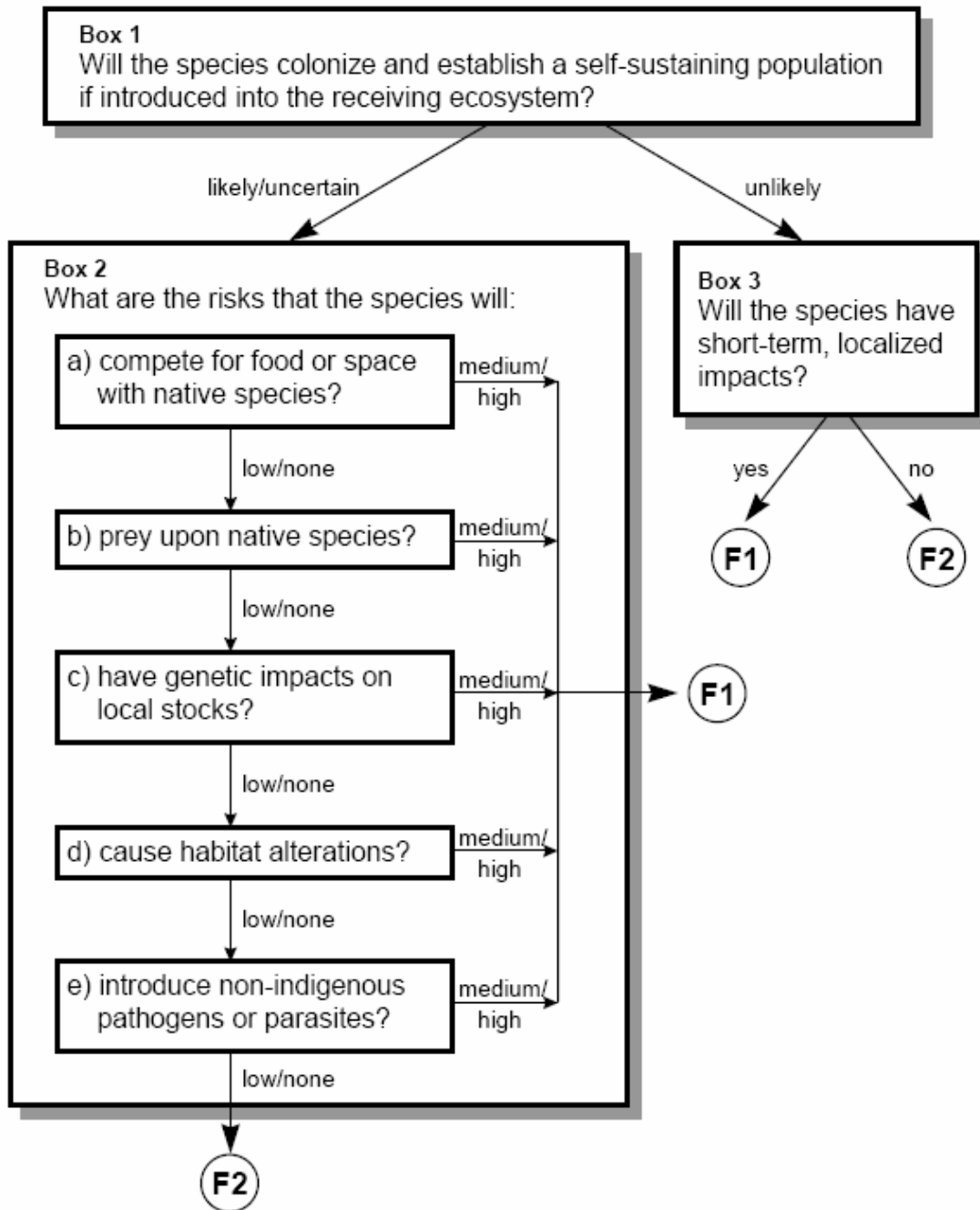
- single inflow conduit barrier appropriate to species cultured

AND

- single outflow conduit barrier

## OMNR Guidelines to Determine if Aquaculture Species will have a Detrimental Impact on a Receiving Ecosystem

(Source: OMNR 2004)



## **STANDARD OPERATING PROCEDURES MONITORING & MAINTENANCE**

### **Monitoring & Maintenance Procedures - Land-Based Facilities**

#### Daily:

- At the start of each day, conduct a visual inspection of the entire facility to ensure that all systems, components and equipment are operating effectively and efficiently.
- Clean screens on all tanks, as required.
- Check inlet and drain lines for obstruction.
- Examine solids waste collection and storage facilities to ensure their effective and efficient operation.
- At the end of each day, conduct a visual inspection of the entire facility to ensure that all systems, components and equipment are operating effectively and efficiently.
- Following any event that increases the risk of systems failure and/or escape (e.g. storms, heavy rains, power failure, suspected vandalism, hosting on-site tours), conduct a visual inspection of the entire facility to ensure that all systems, components and equipment are operating effectively and efficiently and record findings in the Facility Log.
- Record the daily inspection in a log and document any discrepancy from routine and any repairs and/or adjustments (maintain the log on-site for one year).

#### Weekly:

- Examine all principal mechanical systems (e.g. pumps, aerators, filters, etc.) to ensure their effective and efficient operation.
- Measure and record the power consumption of key electrical components (e.g. pumps, blowers) using an amp or watt meter.
- Test all alarm and emergency power systems.
- Record the weekly inspection in a log and document any discrepancy from routine and any repairs and/or adjustments (maintain the log on-site for one year).

## **Monitoring & Maintenance Procedures – Cage Culture Facilities**

### Maintenance Procedures for Nets

- During the open water season, routinely conduct complete inspections of all nets and cage structures. Inspections shall be conducted at intervals not exceeding 30 days and following any event that increases the chances of net damage (e.g. spray ice events, storms, etc). Record observations in the nets log, including any repairs or maintenance conducted.
- Prior to transferring fish into an empty net pen, or at an interval not to exceed 12 months, conduct a complete out-of-water inspection of the net.
- As part of the out-of-water net service, verify the integrity of the net using the Ontario Net Cage Mesh Strength Testing Procedure in accordance with manufacturer's specifications for each net and record all observations in the Nets Log, including any repairs or maintenance conducted (see Appendix). Net that do not retain 66% of their original strength, as defined by the net manufacturer, shall be removed from service.
- Repair all nets, as required, using the skills of trained employees or send the faulty nets to a professional net servicing company for repairs.
- Store all nets that are not being used out of direct sunlight and protected from rodent and insect infestation.

### Maintenance Procedures for Cage Systems

- Surface and Floating Components
  - During the course of daily operations on-site, observe all systems components and equipment (e.g. net connections, mooring lines, hinges, etc.) to ensure that they are functioning effectively and efficiently. Note any potential problems and/or abnormalities and take appropriate actions; record events in the Facility Log.
  - Following any event that increases the risk of systems failure and/or escape (e.g. storms, heavy rains, excessive ice, power failure, suspected vandalism, hosting on-site tours, towing cages containing fish, fish delivery), conduct a surface visual inspection of the entire facility to ensure that all systems, components and equipment are operating effectively and efficiently and record findings in the Facility Log.
  - If any part of the system is observed to be floating lower than the rest of the system, determine the cause and take corrective action. Record all inspections, abnormalities and repairs in the Facility Log.
- Cage Mooring Points
  - Ensure that all knots, screw-pin shackles, etc. are tight, at an interval not to exceed 30 days.
  - Check the substructure to which the mooring points are attached for any cracking or fatigue, at an interval not to exceed 30 days.
  - Check the condition of mooring ropes, chains and cables, at an interval not to exceed 30 days.

- Conduct an annual visual inspection of anchor lines and moorings – by SCUBA where depths permit or by cameras otherwise.
- Test anchor lines annually with a tension meter to confirm that installed performance standards remain in effect.
- Repair or replace defective components as required and record all repairs in the Facility Log.
- Hinge Connections
  - Ensure that retainer bolts on the end of the hinge pins are tight to prevent hinge pins from working in the mounting ears, at an interval not to exceed 30 days.
  - Ensure the rubber mounted bushings are intact to prevent steel-on-steel wearing, at an interval not to exceed 30 days.
  - Check substructure that the hinge assemblies are mounted to for any cracks or obvious fatigue, at an interval not to exceed 30 days.
  - Repair or replace defective components as required and record all repairs in the Facility Log.
- Railings / Net-Hangers
  - Ensure railings / net hangers are completely inserted into the mounting sockets, at an interval not to exceed 30 days.
  - Ensure the mounting sockets are not cracked or splitting, at an interval not to exceed 30 days.
  - Ensure the substructure around the sockets is not cracked, at an interval not to exceed 30 days.
  - Repair or replace defective components as required and record all repairs in the Facility Log.
- Decking
  - Maintain decking in good repair and replace any broken or worn sections promptly to prevent injury to personnel.
- Other Equipment & Components
  - Examine all principal mechanical systems (e.g. pumps, aerators, filters, etc.), at an interval not exceeding 30 days, to ensure their effective and efficient operation.
  - Test all alarm and emergency power systems at an interval not to exceed 30 days and after all significant risk events such as electrical storms.

## Appendix

# ONTARIO NET CAGE MESH STRENGTH TESTING PROCEDURE<sup>2</sup>

## VERSION I

August 2006

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### 1. SCOPE

This procedure specifies the method that must be used in Ontario for the purpose of determining the tensile (breaking) strength of mesh used for the containment of farmed fish. This procedure is intended for use with nets common to the Ontario aquaculture industry. These nets are generally made with knotless nylon mesh with published breaking strengths of between 50 and 250 lbs. This procedure may not be suitable for other types of nets.

### 2. PRINCIPLE

A mesh is extended until it surpasses 66% of the rated tensile strength specified by the manufacturer for the net when new. The test is performed using a suitable apparatus that records or indicates the load at the point of testing. The testing machine is operated at a rate of elongation which is both constant and within prescribed limits. Nets that do not retain 66% of the rated tensile strength specified by the manufacturer for the net when new fail the test and must be immediately removed from service.

### 3. APPARATUS

#### 3.1 Testing Machine

The machine used for testing shall meet the following criteria:

- a) Machine shall include a digital load cell or dynamometer providing direct measurement (in units of force) of the load applied to the mesh. The load cell or dynamometer shall be accurate to within 2.5 lbs (11 N), or 1.0% of the mesh breaking strength, whichever is greater.
- b) The load cell or dynamometer shall have an accurate means of recording the load applied to the mesh.
- c) Machine shall apply load to a single mesh at a constant rate of elongation equal to 10 inches per minute (25 cm per minute), plus or minus 10%.
- d) For testing machines which apply force in discrete steps (such as by way of a hydraulic cylinder with a hand pump), the rate of elongation, per (c) above, shall

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<sup>2</sup> Adapted from British Columbia Net Cage Mesh Strength Testing Procedure - Version 1, March 2002. BC Ministry of Agriculture, Food & Fisheries, National Library of Canada Cataloguing in Publication Data. ISBN 0-7726-4798-4

be the average rate of elongation. During each step, the rate of elongation shall be as close as possible to the average rate required, that is the steps must be consistently applied at a given rate. The maximum mesh elongation for each step shall be 0.20 inches (5 mm). Testing machines of this nature shall be designed such that the user can readily apply the load at a rate that will meet these requirements.

- e) The machine shall engage a single mesh for testing with steel pins or hooks formed from round material with a diameter of 0.1875 inches (5 mm). The pins or hooks shall be so mounted as to remain in direct line with the applied load in order to provide a true reading on the load cell or dynamometer. The pins or hooks shall be smooth and free of any sharp edges or roughness.

### 3.2 Calibration and Maintenance

The dynamometer or load cell from each testing machine shall be calibrated annually in accordance with the manufacturer's recommendations. Testing machines shall also be calibrated annually to ensure that the specified elongation rate is maintained. The owner of the machine shall keep calibration certificates on file, with a copy kept with the machine.

The testing machine shall be properly maintained in order to continue to provide accurate results and to meet the requirements above. This will include replacement of the testing hooks as necessary due to wear, corrosion or roughness.

## 4. TESTING REQUIREMENTS

- 4.1 A net cage must be tested according to the testing protocol in Section 5 of this document at the following locations:
  - a) two locations separated by greater than 10 meters on the underwater portion of the net; and
  - b) one location on the above-water portion of the net.
- 4.2 For each location tested on a net cage, it is mandatory to test 5 individual single-mesh sections.
- 4.3 Test locations shall be representative of the mesh making up the whole net and shall not be located in a previously repaired area. If a net has large areas of repair or is fabricated from different sources of mesh, the test procedure (Section 5) shall be performed on each different mesh type or age of mesh.
- 4.4 Testing shall be performed by pulling the net slack around the area to be tested, such that no outside forces are acting upon the mesh being tested, and maintaining such slack for the duration of the test.
- 4.5 Testing may be performed on dry or wet mesh. Temperature shall be within normal ambient temperatures for Ontario. Tests shall not be conducted on frozen mesh.

**\*NOTE:** 'Mesh size' refers to the distance between the centers of two opposite joints (or knots) in the same mesh when fully stretched; this information should

be obtained from the original tagging on the net cage.

## **5. TEST PROCEDURE**

- 5.1 Testing shall be performed on a single mesh, oriented so that the pillars (bars) of the mesh are engaged over the pins or hooks, not the knots or joints of the mesh.
- 5.2 Mount the mesh over the pins or hooks, and take up the slack.
- 5.3 Apply load at a steady rate of elongation, as defined in 3.1, until the mesh exceeds 66% of the manufacturer's specified tensile (breaking) strength. Record the load.
- 5.4 Repeat for a total of five single mesh sections at the location being tested.

## **6. REPORTING**

Test results shall be recorded on a form that also includes information about the net, including:

- a) Owner of net and net identification number.
- b) Mesh manufacturer and manufacturer's published mesh-breaking strength.
- c) Net fabricator and date of net fabrication.
- d) Accumulated in-water service time.
- e) Size and gauge of mesh and dimensions of net cage.
- f) Date and location of testing, company and name of person doing test.
- g) Information on antifoulant treatment of net, if any.
- h) Whether net was tested wet or dry.
- i) Approximate ambient temperature at test.
- j) Tensile strength test results for each prescribed location, and pass/fail grades.
- k) General comments and notes on overall condition of net.
- l) Signature of tester.

**8. REPORTING FORM**

ONTARIO NET CAGE TESTING RECORD							
Date of Testing:				Net ID:			
Owner of Net:				Name of Company performing testing:			
Name of Contact:				Name of Tester:			
Mesh Manufacturer:				Dimensions: (ft / m)			
Net Fabricator:				_____ x _____ deep:			
Date of Net Fabrication:				Mesh Size (mid knot to mid knot): (in or mm)?			
Accumulated in-water service time:				Gauge: 210 /			
Rated Breaking Strength (lbs / kg):				Tested: Wet or Dry?			
Required Strength (lbs / kg):				Test Temperature (approx):			
Below Water Line:				Antifoulant:			
Above Water Line:							
Tensile Strength Data ( lbs / kg)							
	Test 1	Test 2	Test 3	Test 4	Test 5	Pass/Fail	Initials
Below Water Line 1							
Below Water Line 2							
Above Water Line							
Details of Complete Visual Inspection:							
Repairs Completed:							
Comments:							
Signature of Tester:							