Environmental Issues Concerning Water Use and Wastewater Impacts of Land-Based Aquaculture Facilities in Ontario

FINAL VERSION

Report submitted to:

Ontario Sustainable Aquaculture Working Group

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Executive Summary

An inventory of the production, waste-management and aquatic resources currently being utilized by land-based aquaculture facilities in Ontario was undertaken. In addition, a preliminary list and review of the environmental issues and challenges which face land-based aquaculture facilities in Ontario was developed.

The primary purpose of the project was to define those important environmental issues and challenges that affect land-based aquaculture in Ontario.

By defining the issues, the Ontario Sustainable Aquaculture Working Group (OSAWG) can develop recommendations for the necessary policy strategies and research projects to help overcome them, thereby facilitating the continued, sustainable growth of the Ontario aquaculture industry. The project was not intended to gather proprietary information about Ontario aquaculture facilities, and limits the details reported herein to protect individual confidentiality.

In 2003, the Ontario aquaculture industry produced approximately 4,375 tonnes of fish for human consumption (Moccia & Bevan 2004). Rainbow trout accounted for 4,200 tonnes (9.25 million pounds), with a farm-gate value of $17.0 million. Limited quantities of tilapia and Arctic charr were also produced (approximately 150 tonnes) and other species including brook trout, bass and other fish (approximately 25 tonnes). The industry generated approximately 210 person-years of direct employment plus another 250 person-years of indirect employment. The total economic contribution of the industry to Ontario's private sector is estimated at $60 to $65 million. In 2004, annual production of rainbow trout is estimated to be between 4,000 and 4,500 tonnes, with tilapia, Arctic charr and other fish production remaining at approximately 200 tonnes to 300 tonnes.

It is estimated that there are a total of 196 private sector aquaculture facilities in Ontario that produce fish primarily for human food or recreational fishing. Of these, 188 are land-based fish production facilities. These facilities are estimated to have produced 1,000

tonnes (i.e. 24% of total) of trout as well as other species in 2003. A sub-sample of 16 land-based facilities were selected to conduct detailed interviews. These 16 facilities accounted for nearly 9 million fingerlings and 580 tonnes of production and included hatcheries, food producers, stocking and fee-fishing operations and also government fish culture facilities. The facilities used either ground or surface water sources, and wastewater treatment consisted of within tank settling of solids and/or dedicated solids treatment facilities.

Synopsis of the major environmental and regulatory issues as reported from the review of the sector is:

- Clear definition of what precisely defines a sewage works, and what constitutes a significant alteration of the sewage works requiring an amendment to existing Certificate of Approval is required.
- Conflict between a “mass balance” approach versus a “concentration limit” approach to wastewater compliance, which seriously constrains the expansion of the recirculation sector in Ontario.
- Misapplication of sludge disposal guidelines that currently treat fish manure as industrial waste under the provisions of the Certificate of Aapproval.
- Excessive monitoring requirements for compliance with licences and regulations.
- Excessive application fees for permit reviews and approvals.
- Potential conflict between fish farmers and other users of ground and surface water.

1. Introduction

Ontario's aquaculture industry produced over 4,375 tonnes of food-fish in 2003. Approximately 3,200 tonnes of this production was cultured in open-water cage farms in the Georgian Bay region of the Great Lakes (Figures 1 and 2). All remaining fish production comes from land-based farms located primarily in southern Ontario. Although land-based production is modest by comparison with open-water cage farms, the number of farms is considerably greater. Land-based production facilities encompass a wide range of technology types. These include hatcheries which provide fingerlings to the open-water cage sector, various types of tank, raceway and pond-based food-fish production farms, recreational fishing preserves, fish stocking programs (private and government) and warm-water fish production in semi-closed recirculation systems (e.g. tilapia).

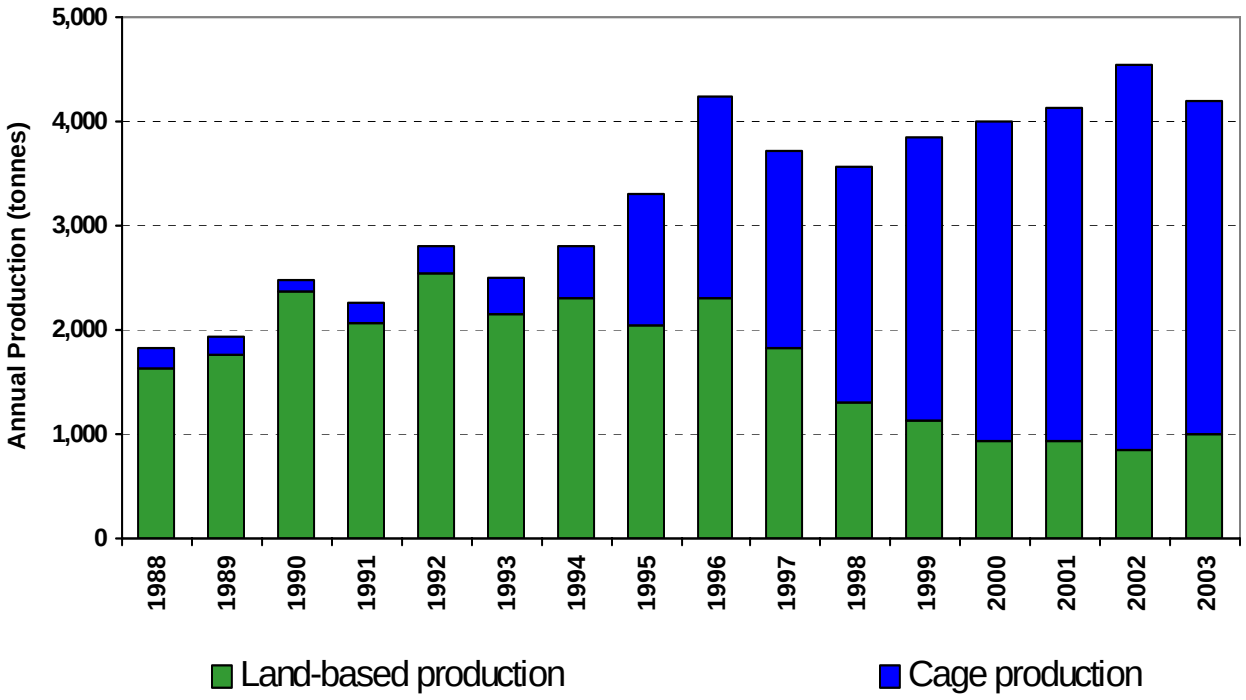
Despite the relatively small production tonnage coming from land-based farms, these facilities may have the potential for a disproportionate impact on the environment. Many of the farms are located near larger population centres within the watershed of the Great Lakes basin. This can result in increased competition for surface and ground water resources, and potential interaction with the many different water users within the watershed.

Land-based trout production facility showing concrete raceways with "in-tank" settling zones.

The legislative control and monitoring of water use and effluent quality for land-based aquaculture is complex, and federal, provincial and municipal government agencies are involved in this regulatory activity (Moccia and Bevan, 2000). The principal legislative tools controlling water use and effluent discharge from land-based fish farms include: 1)

Permit to Take Water (PTTW) and 2) Certificate of Approval (CofA) for industrial sewage works from the Ontario Ministry of Environment (MOE); and 3) an Aquaculture Licence and 4) adherence to the Lakes and Rivers Improvement Act, both administered by the Ontario Ministry of Natural Resources (OMNR).

Figure 1. Comparison of Ontario land-based and cage aquaculture production between 1988 and 2003.

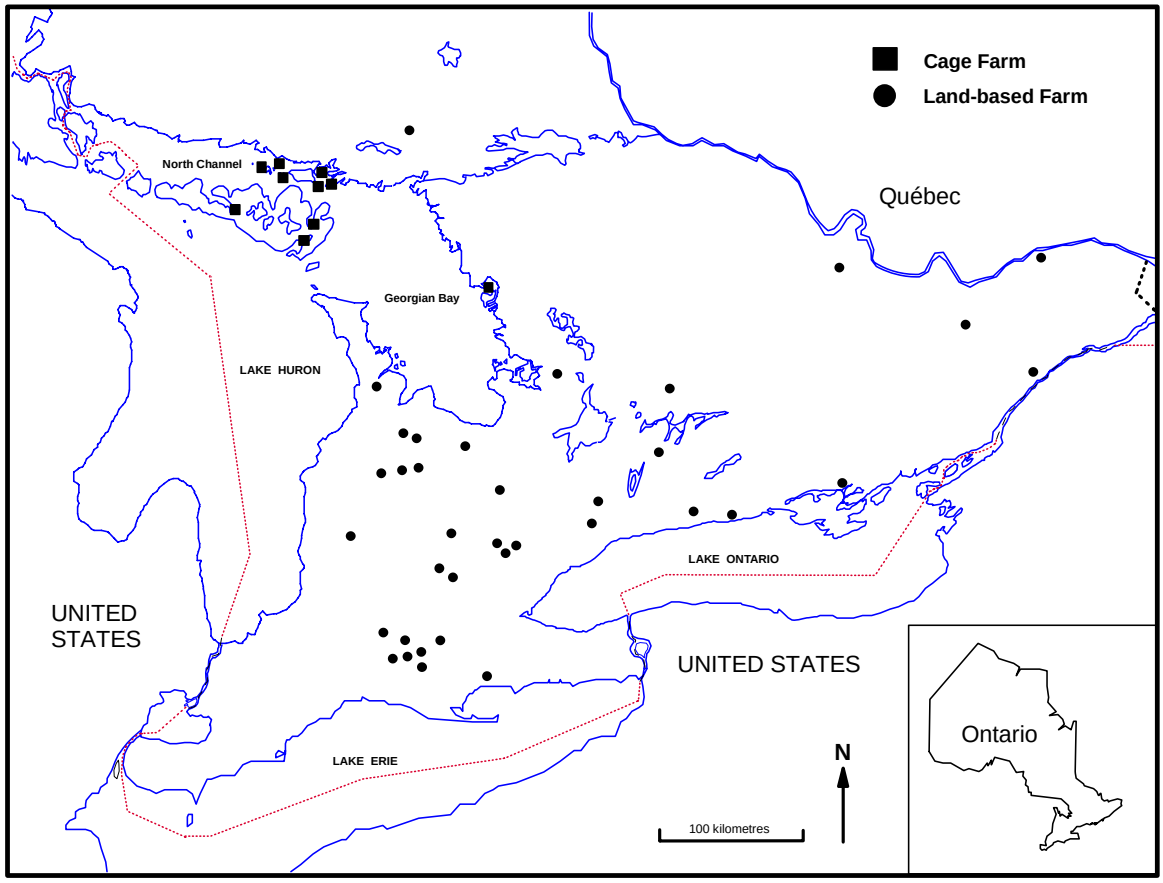


There are several regulatory issues affecting land-based aquaculture that differ from those affecting the open-water cage sector. In particular, the need for a PTTW, CofA and sludge disposal authority required for most land-based farms, presents approval and compliance standards that have no direct counterpart in open-water cage aquaculture.

If aquaculture is to grow in a sustainable fashion in Ontario, it will be necessary to identify and resolve these, and other, regulatory issues and reconcile environmental management strategies with the specific needs of the land-based fish farming community in mind. This is especially important since the open-water cage sector, which supplies

most of the provinces food production volume, is totally dependent upon the supply of juvenile fish that are raised in land-based facilities. Furthermore, research programs will be more effective if they are guided by a better understanding of the contemporary issues that surround the application of our existing environmental regulatory framework to land-based fish farms. In this regard, we have a much better understanding of the issues and concerns viz-a-viz open-water cage aquaculture in Ontario, since most of our current efforts and research initiatives have been directed towards this industry sector.

Figure 2. Map of fish farms in Ontario producing more than 5,000 kilograms of fish for human consumption in 2003.



2. Methodology

A multi-faceted approach was taken to collecting information about land-based aquaculture in Ontario. The Aquaculture Centre of the University of Guelph has conducted ongoing surveys of Ontario's aquaculture since 1988. These annual "AQUASTATS" surveys have focused on fish production for human consumption, employment and overall economic value. Annual fact sheets summarizing the information are available from the Aquaculture Centre website (http://www.aps.uoguelph.ca/~aquacentre). The information collected was used as the foundation for this report.

Questionnaire and Interviews

A number of face-to-face meetings and telephone interviews were conducted with relevant individuals from the various sectors involved in land-based aquaculture. The sessions were designed to document contemporary environmental issues that are unique to land-based aquaculture in Ontario. Consultation with selected primary producers included hatcheries, grow-out facilities, pond-stocking operations and recreational fishing operations. Sixteen facilities were selected to encompass a broad range of type and size. Each facility was visited and the owner /operator assisted with the completion of a survey questionnaire describing:

1. Location
2. Type of facility
3. Species raised
4. Water source
5. Water use
6. Water discharge
7. Rearing facilities
8. Feeding methods
9. Waste treatment methods
10. Cleaning methods
11. Cleaning frequency
12. Waste disposal methods

In addition, personal comments describing the environmental issues and challenges that affect land-based aquaculture in Ontario were recorded.

The staff from the principle provincial regulatory agencies, OMNR, OME and Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) were also consulted for

their viewpoints. In total, 23 individuals were interviewed, with 15 from the private sector, and 8 from the public sector.

3. Land-based Aquaculture in Ontario

3.1. Location of facilities

The geographic distribution of land-based aquaculture facilities is concentrated in the central and south-western region of Ontario (Figure 2). Historically, many of these facilities developed within the Niagara Escarpment region because of access to abundant ground water sources. A subsequent area of development was south-western Ontario (e.g. Tilsonburg & Simcoe) where agricultural diversification was encouraged, especially for tobacco farmers in the mid-1980's. Over the last ten years, most of the growth in Ontario aquaculture has been the result of open-water cage farms expanding in northern Ontario, primarily the Manitoulin Island / North Channel and Georgian Bay regions; with the land-based facilities in southern Ontario providing the source of juvenile fish for the production cage facilities.

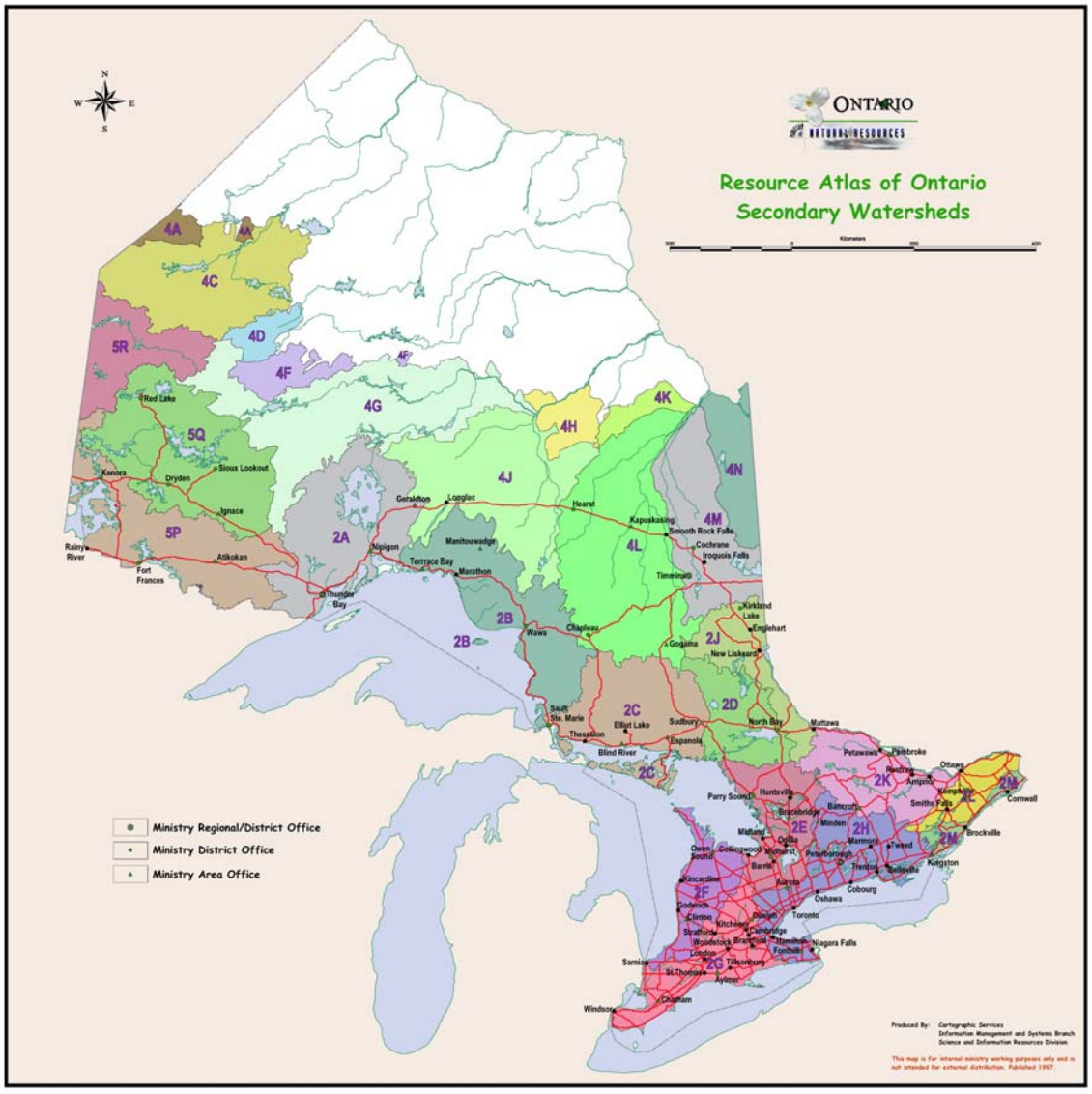
Survey records indicate that that there are currently 196 aquaculture facilities in Ontario. These facilities are primarily private operations, but include the ten Fish Culture Stations operated by the OMNR for stocking purposes, and the Alma Aquaculture Research Station operated by the University of Guelph. Of these 196 facilities, 188 are classified as land-based, and 8 are lake-based.

3.2. Water accessed and returned to watershed

Land-based aquaculture generally accesses either groundwater or surface water for its operation. A few facilities use municipal water sources, an option brought about by recirculating water technology. The quantities of water accessed ranges from those accessing less than 150 litres per minute (lpm) to facilities accessing surface water with flow rates exceeding 15,000 lpm. Nevertheless, aquaculture is generally not a water user per se, virtually all of the water accessed is returned to a surface waterbody.

There is a growing concern about protecting Ontario's water sources and ensuring sustainable supplies. A key part of this is developing watershed based planning and development strategies. Ontario is divided into three primary watersheds, "Great Lakes – St. Lawrence Basin", Hudson Bay Basin and Nelson River Basin. Most of Ontario's aquaculture facilities are located within the "Great Lakes – St. Lawrence Basin watershed. Each primary watershed is sub-divided into secondary watersheds (Figure 3), which are sub-divided into tertiary watersheds. The majority (81%) of the land-based aquaculture facilities lie within the five secondary watersheds of Georgian Bay, Lake Huron, Lake Erie, Lake Ontario and the Ottawa River (Figure 4 and Table 1).

Figure 3. Secondary watersheds of Ontario [1]



[1] See accompanying CD for electronic version.

Figure 4. Number Of Land-Based Aquaculture Facilities By Secondary Watershed In Ontario (2002).

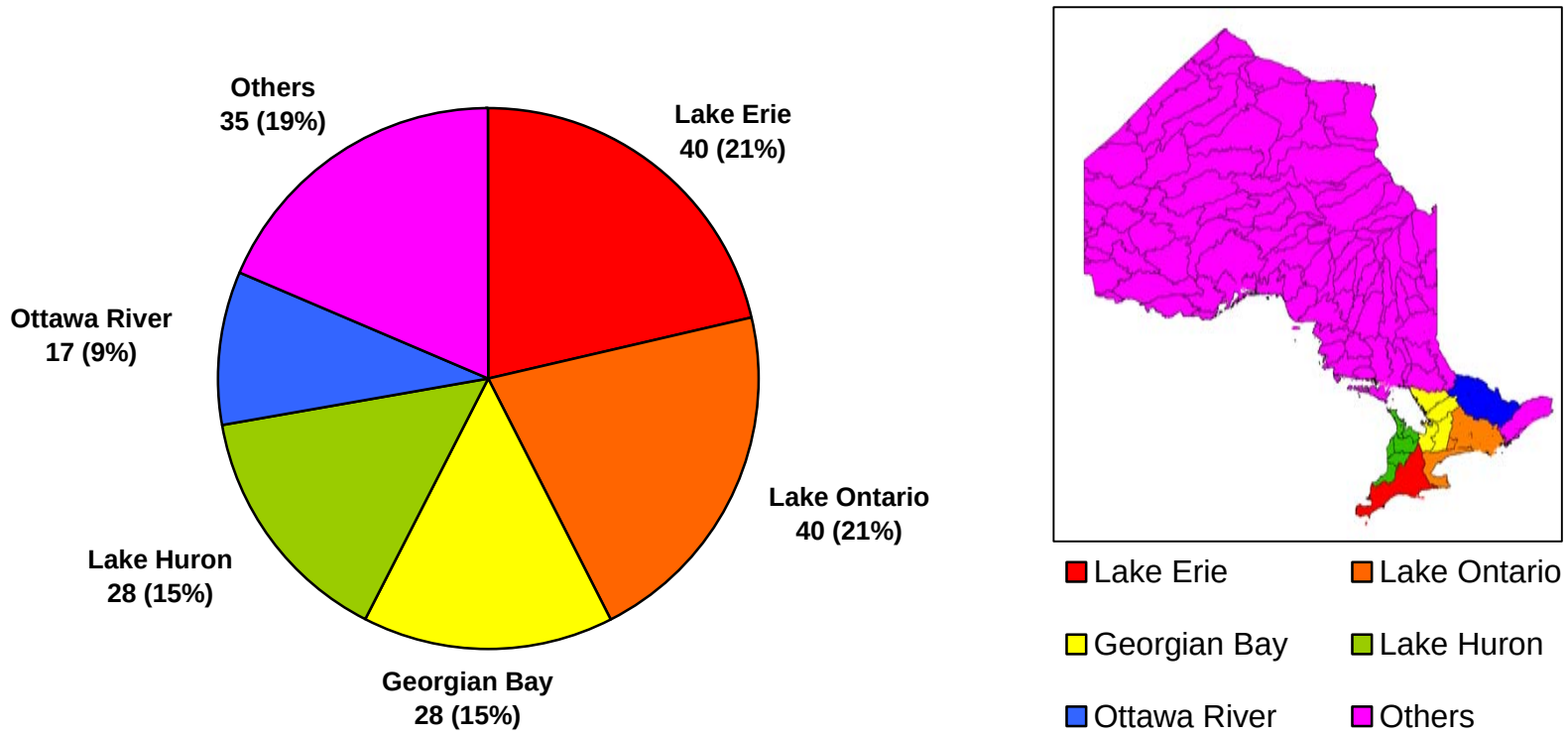
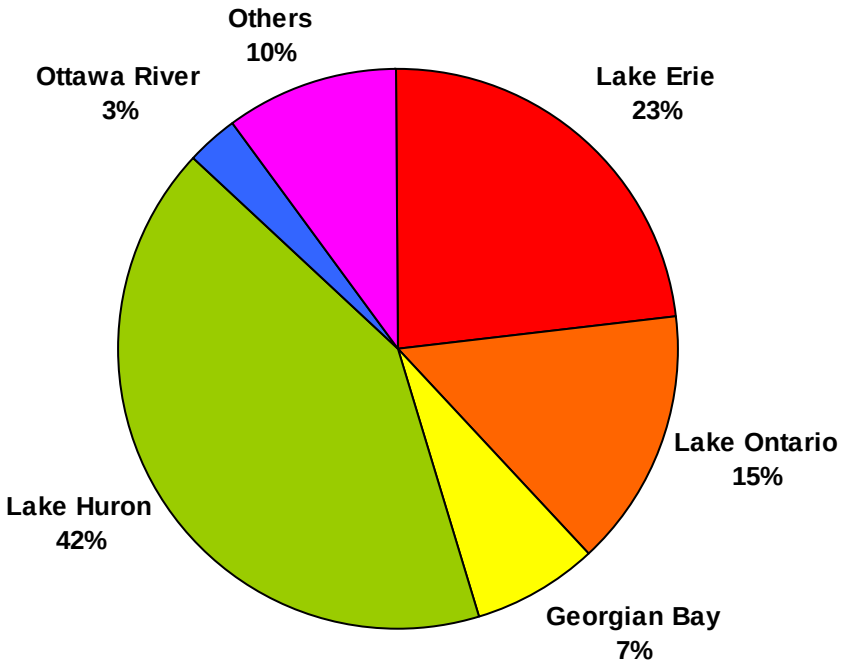
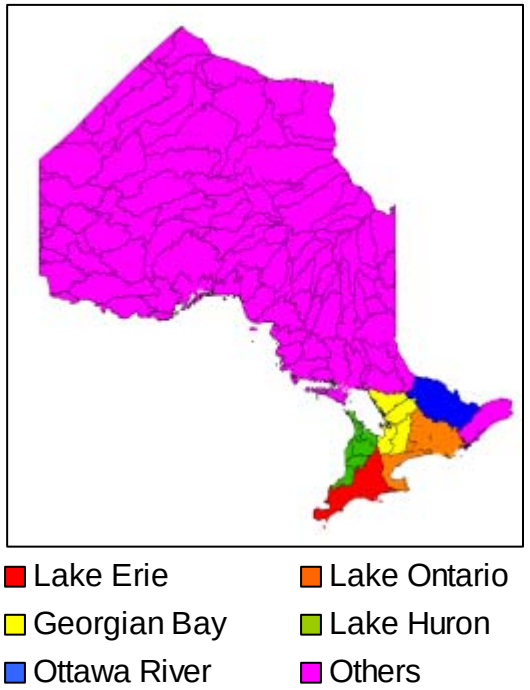


Table 1. Distribution Of Ontario Land-Based Aquaculture Facility Type By Secondary Watershed (2002).

2º Watershed code	Description	Hatchery	(%)	Stocking	(%)	Food Prod	(%)	Fee-fish	(%)	TOTAL	(%)
2A	Lake Nipigon	2	3.3%	1	1.5%	1	1.5%	1	1.0%	**3**	**1.6%**
2B	Lake Superior	1	1.7%	1	1.5%	0	0.0%	0	0.0%	**1**	**0.5%**
2C	North Channel	1	1.7%	1	1.5%	2	3.1%	6	6.1%	**9**	**4.8%**
2D	French River	0	0.0%	0	0.0%	1	1.5%	0	0.0%	**1**	**0.5%**
2E	Georgian Bay	6	10.0%	8	11.9%	9	13.8%	16	16.2%	**28**	**14.9%**
2F	Lake Huron	12	20.0%	13	19.4%	12	18.5%	14	14.1%	**28**	**14.9%**
2G	Lake Erie	10	16.7%	15	22.4%	19	29.2%	18	18.2%	**40**	**21.3%**
2H	Lake Ontario	12	20.0%	16	23.9%	12	18.5%	24	24.2%	**40**	**21.3%**
2J	Lake Timiskaming	2	3.3%	2	3.0%	0	0.0%	1	1.0%	**3**	**1.6%**
2K	Ottawa River	4	6.7%	3	4.5%	4	6.2%	12	12.1%	**17**	**9.0%**
2L	South Nation	3	5.0%	3	4.5%	2	3.1%	2	2.0%	**5**	**2.7%**
2M	St. Laurence River	2	3.3%	1	1.5%	2	3.1%	1	1.0%	**4**	**2.1%**
4L	Moose River	2	3.3%	2	3.0%	1	1.5%	2	2.0%	**4**	**2.1%**
4M	Abitibi River	1	1.7%	0	0.0%	0	0.0%	2	2.0%	**2**	**1.1%**
5P	Rainy Lake	1	1.7%	1	1.5%	0	0.0%	0	0.0%	**2**	**1.1%**
5Q	Lac Seul	1	1.7%	0	0.0%	0	0.0%	0	0.0%	**1**	**0.5%**
TOTAL		**60**	100.0%	**67**	100.0%	**65**	100.0%	**99**	100.0%	**188**	**100.0%**

Figure 5. Percentage Distribution Of Ontario Land-Based Aquaculture Production By Secondary Watershed (2002).





3.3. Types of land-based aquaculture facilities

A great diversity of land-based aquaculture facilities are found in Ontario. Some of these facilities were developed nearly 40 years ago when the Ontario Fish and Game Act first permitted the culture and sale of selected trout and bass species. Most facilities are owner-operated and a number of them combine aquaculture with other farming practices, e.g. tobacco, corn etc. For classification purposes, facilities have been categorized as 1) *hatchery* (having brood fish and raising fingerling-sized fish), 2) *stocking* (provide fish for pond stocking), 3) *food producer* (produce market-size fish for direct human consumption), and 4) *fee-fishing* (provide recreational fishing). Many facilities operate under more than one category (Table 1).

A wide range of fish species (37) and a few species of crayfish are permitted for aquaculture production in Ontario. The vast majority of producers focus on salmonid species (primarily rainbow trout, Arctic charr and brook trout) with a few growing tilapia, bass, baitfish species, walleye and yellow perch. Ontario aquacultural production is estimated to be over 4,375 tonnes of fish (all species) in 2003. Of this, land-based aquaculture accounted for an estimated 1,000 tonnes (24%), with 90% of this being produced within five watersheds (Figure 5).

The larger land-based facilities are primarily geared towards providing juvenile rainbow trout (approximately 4-6 month age, 25 to 50 grams weight) for the lake-based cage facilities. Typically, this results in peak production in the late spring and early summer, with a second peak, for some facilities, in the late fall.

3.4. Surveyed land-based facilities

Sixteen land-based facilities were selected for a detailed survey. These facilities were located in four secondary watersheds (Georgian Bay, Lake Huron, Lake Erie and Lake Ontario) and accounted for 580 tonnes of fish production in 2003 (49 % of land-based total) and included the following types: 15 hatcheries, 11 fish stocking, 13 food producers and 2 fee-fishing operations. A complete breakdown is given in Appendix I.

4. Major Environmental Issues and Concerns

4.1. Summary of environmental issues and concerns

Land-based aquaculture can potentially affect the environment in a variety of complex ways including: water use, habitat degradation, fish escapement, pathogen transfer and disease impacts. The availability of water is a fundamental prerequisite of land-based aquaculture. Both groundwater and surface water are used, and their selection is based upon quality and quantity criteria (e.g. temperature, water chemistry and cost of extraction). Historically, Ontario aquaculture developed in the Western Central region, where abundant groundwater supplies are often associated with the overburden aquifers and many facilities use free-flowing springs or pumped wells. There are few land-based facilities that use surface water sources exclusively, although a significant producer of trout in the 1990's pumped water directly from Lake Ontario[2]. Typical flow-through culture technology for rainbow trout in Ontario can produce 4 to 12 kilograms of fish per year for every litre per minute of water available. Higher levels of production can be realised with additional water treatment and varying degrees of water re-use. Nevertheless, large quantities of water are accessed and this raises numerous issues including use of a common resource, allocation of resources etc.

The vast majority of land-based fish production is based upon flow-through culture techniques. This technique uses the water to transfer waste and excess metabolic products away from the fish rearing tank (or pond) to the receiving surface water. As a result, habitat degradation can result if the quantity of waste products exceeds the assimilative capacity of receiving watercourse. Areas of potential concern include: biological oxygen demand, nutrient loading, chemicals and pathogenic organisms dispersed into the waterways. Changes in the physical characteristics, e.g. temperature and flow rate may also occur.

Other areas of concern involve the potential for the cultured fish to escape, resulting in the potential for inter- and intra- species competition and health management concerns.

[2] Coolwater Farms Ltd. produced nearly 500 tonnes per year at its peak in 1990.

All of the above concerns are, to varying degrees, controlled and regulated by a combination of legally imposed regulations, and a level of self-regulation by the industry and market forces.

4.2. Overview of legislative controls

There are three principle areas of legislative control of land-based aquaculture in Ontario, and they govern: the amount of water that can be accessed; the quality of the water returned to the environment; and the species of fish that can be cultured. In addition to these restrictions, other controls potentially include: feed ingredient use, disease control and product quality. These controls are primarily regulated by provincial and federal agencies, but local municipalities are also involved. The MOE and the OMNR are the key provincial agencies, and Fisheries and Oceans Canada being the key federal agency. A summary of the legislation affecting land-based aquaculture in Ontario is given in Appendix II and Moccia and Bevan (2000). Full details of Ontario's legislation is available online at:
http://www.gov.on.ca/MBS/english/publications/statregs/index.html

The mandate of the MOE includes the management of surface and groundwater quality and quantity in Ontario. Several pieces of legislation provide the authority and responsibility of MOE to achieve this mandate. The Ontario Water Resources Act, section 34, regulates the taking of more than 50,000 litres per day via the PTTW; the Ontario Water Resources Act, section 53, details the requirements affecting the construction and operation of a "sewage works" which controls the discharge in excess of 10,000 litres per day into a watercourse. Other legislation includes the Environmental Protection Act and The Environmental Bill of Rights and the regulations made under these acts.

The MOE provides several documents describing how to comply with these control measures (see accompanying CD).

- "Guide for Applying for Approval of Permit to Take Water" – Interim Guidelines (MOE 2000).
- Protocol for Updating Certificates of Approval for Sewage Works" (MOE 2002).
- "Guide for Applying for Approval of Permit to Take Water (MOE 2000).
- "Interim Environmental Guidelines for Salmonid Aquaculture Facilities in Ontario" (MOE un-dated document).

The federal government is responsible for fisheries in Canada, as enabled by the Fisheries Act of Canada and is enforced by the Department of Fisheries and Oceans Canada. From this act, the Ontario Fishery Regulations confers the authority for regulating certain aspects of fish and fisheries management in Ontario to the OMNR.

The mandate of the OMNR is to protect and manage Ontario's natural resources, and also includes a responsibility for the water resources, e.g. flood, drought and erosion hazards (thus complimenting MOE's mandate). A number of Acts and regulations confer the authority to OMNR and include:

- The Fish and Wildlife Conservation Act
- The Lakes and Rivers Improvement Act
- The Conservation Authorities Act
- The Ontario Water Resources Act
- The Public Lands Act

The OMNR also plays a role in managing the Great Lakes and other Boundary Waters via cooperation with agencies that include: the International Joint Commission, the Great Lakes Commission, the Council of Great Lakes Governors and a number of inter-provincial and international water control boards.

Additional regulations are enforced by federal and provincial agencies. These include Health Canada, Environment Canada, OMAFRA and the Conservation Authorities.

The environmental issues and concerns identified during the survey interviews involved either legislative and regulatory requirements or operational and external factors and are summarized in Table 2A and Table 2B, respectively.

Table 2A. Summary of Legislative / Regulatory Environmental Issues Affecting Land-based Aquaculture in Ontario.

A.	Legislative Issues	Aspects Involved
1.	How Cof A applied	1. Effluent classified as "industrial waste" not "agricultural manure". 2. Currently entire facility is regulated. 3. Control of discharge concentration and not mass loading is flawed. 4. Review process is too slow.
2.	Requirements for CofA	1. Inconsistent requirement to have CofA. 2. Some farms operated for many years "without problem". 3. Retroactive approvals guidelines ("Grand-father clause") unclear. 4. Application process too complex. 5. MOE policy is not carried out across all levels. 6. Testing of some water parameters is very expensive. 7. Current detection limits are too close to compliance limits.
3.	Cost of Cof A.	1. Excessive application cost involved. 2. No "small-farm" exemption. 3. System limits incentive to develop new methods.
4.	Issues with PTTW	1. Application process takes too long. 2. Monitoring requirements can be excessive. 3. Reduction in permit duration may affect business viability. 4. Free-flowing springs should be exempt of PTTW. 5. Concept of "water use charge" is of concern.

Note: CofA: Certificate of Approval (Sewage)
PTTW: Permit to Take Water

Table 2B. Summary of Operational and/or External Environmental Issues Affecting Land-based Aquaculture in Ontario.

B.	Operational Issues	Aspects Involved
1.	Urban expansion	1. Fish farms do not have minimum setback distance. 2. Potential conflicts between urban & rural lifestyles.
2.	Dead-stock disposal	1. Cost and availability of disposal methods
3.	Imported products	1. Food safety concerns of imported products and costs of the different standards applied.
4.	Nutrient management	1. How will fish farming be classified? (industrial or agricultural) 2. Size of land-base to dispose of waste products.
5.	Use of water.	1. Security of water availability for fish farming.
6.	Use of chemicals	1. How are these to be regulated in a "small industry"
7.	Animal care and welfare	1. Increased awareness of welfare issues by public. 2. Increased legislative controls, especially for government facilities.
8.	Liability issues	1. Increased influence of "due diligence" in workplace. 2. Current Cof A may not include all "chemicals" or other hazardous materials used.
9.	Confidentiality	1. Changes to legislation and protection of individual rights balanced against need for government information systems.
10.	Processing standards	1. Requirement for Ontario standards to counter cheaper imports. 2. Increased interest in organic products.
11.	Increased bio-security awareness.	1. Growing concern for transfer of disease causing organisms and loss of genetic diversity.
12.	Communication	1. Some interviewees believe MOE responds only 'reactively'. 2. Fish farmers believe they are blamed for water problems without due evidence of their role in problem. 3. Appeals process is difficult, use of courts is excessively costly. 4. Aquaculture experience in MOE/OMNR could be improved. 5. Permits conditions often lack scientific basis. 6. MOE does not recognize "stewardship". 7. Transfer/reissuing of licences can be too slow.

Note: Cof A: Certificate of Approval (Sewage)
PTTW: Permit to Take Water

4.3. Legislative and regulatory issues and concerns.

Various Certificates of Approval are required by the Ontario Water Resources Act and the Environmental Protection Act for specific activities related to sewage and other works. While several classes of sewage works are exempt, e.g. agricultural drainage works, aquaculture facilities are not.

Aquaculture is a recent form of agriculture that has been forced to fit within existing legislation that has not been specifically developed to accommodate the unique requirements of this sector. For example, the requirement for aquacultural facilities to obtain a CofA for Industrial Sewage Works, is based primarily upon a historical complaint that required existing legislation to rectify a problem rather than a scientific assessment and risk perspective that was incorporated into an appropriate legislative instrument.

> **The classification of fish manure as "industrial sludge" is widely regarded as the fundamental issue affecting land-based aquaculture in Ontario. The primary environmental issues would be alleviated or resolved if aquaculture were under the agricultural umbrella, similar to all other livestock farming practices. This may well be addressed in the upcoming implementation of the Nutrient Management Act, although it is yet to be determined precisely how aquaculture waste will be dealt with by this new Act.**

The requirements for the approval of an industrial sewage works take the approach that the **entire aquaculture facility is treated as a sewage works**. This generalized approach is believed to be unreasonably restrictive for aquaculture facilities. As a consequence of this approach, all changes and repairs to the existing facility appear to trigger the need for an amendment to the CofA, - an expensive and time consuming undertaking. However, in practice, the subjective assessment of what type and magnitude a change triggers the requirement for an amendment is faced by both the facility operator and the

environmental officer. This is a situation which leads to disparities in interpretation and enforcement across the province.

The contention by many people interviewed, is that an aquaculture facility is better regarded as two separate entities for the purposes of the CofA. The first entity being the "rearing facilities", i.e. the fish holding tanks and all those structures that support them (e.g. water, air and feed supply). The second entity is the "wastewater facility", i.e. where the water is treated prior to its return to the receiving water body. Simplistically, the "rearing facilities" should be regarded as a "black box" since it should not affect the final discharge from the "wastewater facility". Providing the original design and standard operating procedures of the "wastewater facility" are correct and maintained – compliance with a CofA will be achieved.

The general standard for current Cof A's at land-based aquaculture facilities requires that discharged water have total suspended solids and total phosphorus at or below 5 mg per litre above background, and 0.05 mg per litre absolute, respectively[3]. These values are based upon average Ontario water quality considerations and not on the assimilative capacity of the receiving water. By assessing the concentration of effluent discharge (amount per unit volume), the unfortunate paradigm "dilution is the solution to pollution" is perpetuated. Consequently, efforts to reduce the quantity of water required to raise fish are severely hindered. Well established techniques to recirculate a large proportion of the required water supply (exceeding 95% of the daily volume) can not comply with existing discharge regulations because of these 'absolute' concentration limits on phosphorus. Thus, these land-based recirculating aquaculture facilities are forced to operate by discharging into municipal sewage works, or to have no off-property discharge what-so-ever, which is difficult to accomplish. A temporary and illogical set of solutions. The ever increasing demands upon Ontario's groundwater and surface water resources requires a review of the fundamental premise that 'absolute' discharge concentration is the parameter to control in aquaculture. A more rational approach would be to control the

[3] Ministry of Environment, (Draft Document, un-dated). Interim Environmental Guidelines for Salmonid Aquaculture facilities in Ontario. 20 pp.

absolute amount discharged and base this upon the assimilative capacity of the receiving waters – in other words, use a “mass balance” approach for recirculation systems.

The apparent disparity, and inconsistent requirements of the existing CofA’s in aquaculture does little to foster a collaborative approach to environmental management. Some aquaculture facilities were established before the requirement for CofA’s were established in 1987, and there is a commonly held belief that these are exempt under a “grandfather clause”. However, almost any change to the operation or physical facility can trigger the legal requirement for a review by MOE, and the subsequent requirement for a CofA. The current cost of applying for a CofA is $6,200 (minimum) and is independent of the size of the works facility proposed. There is no “small-farm” exemption for a CofA, as present regulations make no distinction between large and small facilities (e.g. Community Fisheries Involvement Programs (CFIP) are not exempt from the requirement to have a CofA). The creation of a “small-farm” exemption or an MOE endorsed “short application” might be one approach to pursue. (See comments on Nutrient Management Act and approach taken with Nutrient Management Strategy’s for “small farms”.)

The application process for a CofA is complex and, for many facilities, a private consultant would be required to complete a complete application. The type and degree of reporting stipulated on some CofA’s is both inconsistent and arguably excessive. There appears to be a lack of scientific basis for the permitting requirements. Furthermore, once the CofA application has been approved by the MOE, the opportunity to appeal the imposed conditions is time limited. Once approval is obtained, enforced ongoing water quality monitoring (e.g. total suspended solids, total phosphorus) can result in additional costs exceeding $1,000 per annum. In part, because measurement of total phosphorus, at the required levels, necessitates an accredited commercial laboratory analysis.

The current CofA process limits the incentive to develop new methods of wastewater treatment. Aquaculture is a relatively new practice and many of the operating methods and procedures have shown considerable improvement over a very short time period.

Efforts to improve waste management are hampered by the present system which requires costly amendments to the CofA. that may be triggered by a) changes to existing equipment, processes, production rates or plant expansion or b) MOE staff identify the need for a more in-depth assessment (see MOE 2002). The minimum cost for an amendment to a CofA is $2,000. With few clear guidelines as to what level of change requires an amendment, disparity in enforcement is apparent.

Related to the issue of how best to manage the potential environmental impact of land-based aquaculture is the approach advocated by those that favour the prediction of waste outputs based upon known feed inputs and culture methods (e.g. Cho and Bureau 1998). This approach relies upon a bioenergetic analysis of the system to calculate expected waste-water nutrient outputs. Fundamental to the success of this approach is that the model is valid, and that the facility is operated in accordance with the model. Nevertheless, this approach is similar to Ontario's "Clean Air Program" whereby acceptable levels for a given vehicle emission are established and compliance is periodically checked. This "modelling approach" is complimentary to the development of Standard Operating Procedures and self regulation. Some progress has been made by the Ontario Aquaculture Association to develop "Best Management Practices" in an effort to reduce the environmental impact of aquaculture. For example "Management Practices for Sustainable Aquaculture in Freshwater" (OAA 2002) and "Guide for Fish Containment in Land-Based Aquaculture Facilities" (OAA 2002). A move towards self-regulation is not without its implementation challenges, which include enforcement and accountability. However, for a small sector, where the environmental risks are minimal, it is an approach that should be considered.

The water accessed by an aquaculture facility can be reduced to two fundamental purposes. One is to carry oxygen to the fish and the second is to remove metabolic waste from the rearing environment. The water is used as a transport medium. Virtually all of the water accessed by aquaculture facilities is returned to the watershed – some minor losses occur, that include evaporation and retention in fish carcass. Nevertheless, consideration must be made that the removal of groundwater and its subsequent discharge

into a receiving surface-water body creates a movement of water that may not naturally occur. The regulation and monitoring of actual groundwater removal to ensure it balances recharge rates is a valid concern. When one notes that many land-based aquaculture facilities are located at the origins of a surface water course, aquacultural facilities can be regarded as an integral part of the overall water cycle.

There is a growing concern that access to water is under ever increasing pressure, primarily from higher per capita usage and population growth. Although the argument that aquaculture is not a water user per se is made, the recently proposed initiative to implement a "water use charge" requires careful consideration. While large volumes of water are frequently accessed by aquacultural facilities, the vast majority of this water is both returned to the system, and is also often a very important portion of the stream flow. The general principle of responsible use of resources is not necessarily achieved by implementing a "user fee". Aquaculturist have a vested interest in the sustainable availability of water, and their role as stewards of water resources is more appropriate than that of the industry being perceived primarily as only a consumer of the resource.

Of significant importance to all land-based aquaculture facilities is the Ontario "Low Water Response", which exists to ensure that the province is prepared in the event of low water levels that can result from environmental as well as anthropogenic causes. As such, the aquaculturist is just one of many users, and will have to defend their right to access the water. Compulsory reductions in water use will require prudent planning to avoid disaster at aquaculture facilities. The MOE is quickly moving towards a watershed-based source protection, and is restricting development in some areas. For example, the proposed Greenbelt Protection Act, 2004 is a first step toward the creation of a permanent Golden Horseshoe greenbelt.

Issues involving the PTTW were considerably fewer than those involving the CofA, with several general concerns overlapping both areas of legislation. The issues involving the PTTW were primarily the time required to process applications, and the conditions attached to the permits issued. The application and renewal process for the PTTW is

often lengthy, exceeding two years in some cases. This delay becomes significant when facilities are being commissioned, as well as when they are sold. The issue of delay may be compounded by the recent reduction in the duration of some permits (from 10 to 5 years). The reduction in the duration of a PTTW can have a profound impact upon the value of an aquaculture business which is dependent upon a secured water source. Some recent PTTW have had conditions attached that include very detailed monitoring requirements (e.g. flow gauges and extensive daily record keeping), an additional expense that may not be fully justified. The problems with accurate monitoring of water flow, especially from free-flowing spring and surface sources, are not trivial. The requirement for daily monitoring may be an unnecessary frequency where many years of consistent water taking information is available. Furthermore, it would appear that technical support from the MOE for these problems is not always available.

Several examples of agencies being "complaint driven" in their interaction with aquaculture facilities were noted by interviewees. It would appear that all complaints, no matter how trivial, must be investigated by the MOE as there is no provision for minor issues to be classified as a "nuisance complaint" (as in terrestrial agriculture). This issue is further magnified by the approach that the fish farmer is often regarded as the principle cause of all water related problems, and thus incurs significant cost to prove otherwise. Somewhat of a, 'guilty until proven innocent' scenario for the farmer. Communication problems between the regulatory agencies and the client group were voiced – from both sides. The current method of control is primarily via regulations and a reactionary approach to these types of issues. Typically, this results in an adversarial, rather than collegial, attitude on both sides, and results in a disparity in how problems are solved. Limited manpower and aquacultural experience of the regulatory agencies, primarily at the field level, and a pioneering and independent spirit, typical of many aquaculturist's- do little to help this situation.

4.4. Operational and external environmental issues and concerns.

Operational issues revolve around two central themes. First, there is growing pressure on available resources, that include both water and land use. Second, aquaculture is still a very small player and thus has the potential to be overlooked in the planning process, be it for resource allocation or instigation of legislative measures.

The ever increasing spread of urban development and the conflict between urban and rural lifestyles will almost certainly increase, and is already a serious issue for many terrestrial farms, including aquatic farmers as well. The Ontario Ministry of Agriculture, Food and Rural Affairs has established minimum setback distances between residential and agricultural areas. However no such formula exists to separate fish farms from residences. Residential development often includes individual well and septic systems, both of which can directly affect an established fish farm, as can the development of golf courses and other recreational facilities demanded by an urban population.

The disposal of dead-stock and the recycling of fish processing wastes is becoming more onerous and expensive. Recent restrictions to the transport of animal products across the US border(the result of BSE concerns) have required more local disposal. Previously, these products had a “value” and were used in the manufacture of other animal feeds, e.g. in mink feeds. While improvements to fish processing procedures produce better yields and novel processing, e.g. minced fish nuggets and sausage, have reduced the “waste” – there will always be a non-edible component to dispose of. Furthermore, increased standards of waste disposal, e.g. reduced protein and fat levels permitted in municipal sewage, can have significant economic implications to a small industry.

The “National Code on Introductions and Transfers of Aquatic Organisms” targets salmonids while ignoring “bait fish” and other non-salmonids, e.g. tropical fish and plants and live fish imported for food. Additionally, there is nothing covering the shipping water and where it is discharged.

The Nutrient Management Act (2003) (NMA) provides the legislation for province-wide standards for the management of nutrients generated through agriculture and other practices (e.g. municipal sewage, pulp and paper sludge). Under the NMA, fish farms are defined as agricultural operations and cultured fish are defined as farm animals. Consequently, the regulations will apply to aquaculture. The NMA provides the authority for establishing:

- Requirements for a Nutrient Management Plan (NMP) and a Nutrient Management Strategy (NMS),
- Regulations affecting the use and application of nutrients to the land,
- Minimum separation distance between land application and surface waters,
- Categories of agricultural operations and standards of operation.

Research efforts are in progress to determine the quantity and composition of fish manure that is generated by land-based fish farms. Indications are that fish manure is very similar to other animal manures (Naylor, Moccia and Durant, 1999) and vacuuming solids from settling areas results in a liquid manure of approximately 4% solids[4]. Currently, the quantification of Nutrient Units that apply to fish farms is being developed. However, it is assumed that none of the land-based farms in operation will generate more than 150 Nutrient Units annually (i.e. Category 2 operations) with a phase in date of 2007. New or expanding facilities will be expected to comply with all the regulations from start-up.

Food safety and the use of chemicals in the production of food has become a major focus of several government agencies and consumer groups. This is a very large area of concern and is not specific to land-based aquaculture. Educational programs are being developed (e.g. the Livestock Medicines Education Program by OMAFRA) as are increased methods for tracking of feed ingredients and tighter controls of fish processing. The ability to detect increasingly smaller quantities of chemicals has highlighted the need for a public education program to overcome “media hysteria”. Concern about the use of non-regulated therapeutants and potential abuse of “emergency release” procedures will be directed at aquaculture along with all other agricultural practices. For

[4] Personal communication with Steve Naylor, Ontario Ministry of Agriculture, Food and Rural Affairs.

the most part, aquaculture is one of the few food production systems that can show a serious reduction in antimicrobial use through improved husbandry and codes of practice.

Increasing complexity of the workplace and an increasing climate of litigation will affect all aspects of agriculture – including aquaculture. Ontario has well developed occupational health and safety standards, and the Ontario Farm Safety Association Inc. has created some aquaculture related materials to increase awareness of the risks.

Finally, there is growing concern and awareness of issues involving biosecurity, animal welfare and organic farming. These concerns are not specific to land-based fish farming, but neither do they not apply just because the industry is “small”, or fish are “cold-blooded”! In many respects, aquaculture has the opportunity to lead by example.

5. Recommendations for OSAWG

5.1 Examine possible regulatory changes

A change in the regulatory structure as it pertains to aquaculture is required for sustained growth of the industry. Because the OSAWG committee includes representation from many private and public sector parties, it is in a unique position to debate the following suggested changes:

- Consider moving aquaculture under an 'agriculture' umbrella as far as regulation is concerned, and discontinue use of CofA as the primary instrument to control waste-water discharge from land-based farms.
- Treat aquacultural manure as agricultural manure and not as industrial sludge.
- Use the NMA to regulate environmental management of land-based fish farms. This will likely be the approach taken by government in the near future in any event.
- Encourage the use of, "Standard Operating Procedures", "Nutrient Management Strategies" and/or "Nutrient Management Plans" to control the waste disposal from land-based facilities.
- Consider the merits of a, "Small Farm" exemption to the existing CofA, or future control instrument.

5.2 Potential Research Areas for OSAWG

The mandate of OSAWG is primarily to support the review and development of appropriate technologies and other practices for environmentally sustainable aquaculture in Ontario. The following potential research initiatives are presented without priority, and are provided to initiate further discussion by the OSAWG committee.

- Model a comparison of mass-balance versus absolute concentration limits of total phosphorus and total nitrogen from flow-through and recirculation systems, with the aim of determining the net annual loading from each type of farming system producing similar quantities of fish biomass.

- Investigate waste-water treatment methods suitable for retrofitting existing, small-scale fish farm facilities, to improve effluent quality.
- Evaluate various waste-water sampling methods, e.g. duration, frequency, continuous vs. composite etc., to help design optimal methods of water sampling which are economically practical, and which give appropriate information about annual nutrient and other waste outputs.
- Evaluate water flow-monitoring methods and equipment, that will allow for cost-effective PTTW compliance.
- Examine novel phosphorus removal strategies for discharge compliance from recirculation facilities, e.g. precipitation/chelation and hybrid membrane filter technologies, as well other, emerging chemical adsorption technologies.
- Examine composting and other appropriate technologies and/or methods for dead stock disposal. Develop a 'Recommendations' document for dead stock disposal for aquaculture.
- Evaluate how "International Standards", e.g. ISO 14000, could be used instead of, or in conjunction with, regulatory approaches to achieving environmental standards and compliance.
- Work in conjunction with MOE to identify minimum required changes that result in the need for an enforceable CofA review and amendment.
- Examine metal and other xenobiotic(eg. antimicrobial or other therapeutant) levels in aquacultural manure produced at land based fish farms, and collected in waste treatment systems.
- Determine the animal-unit equivalents for various fish sizes, in order to aid in the calculation of land-application rates and other best management practices for the spreading and disposal of fish manure. Develop a simple spreadsheet that farmers can use to assist with land application calculations.
- Undertake studies to characterize and measure the settling characteristics of fish manure to aid in the improved design of waste clarifiers. For example, determine particle size distribution for various manure types, and measure settling rates and scouring velocities for these particles.

- Evaluate the macro- and micro- nutrient composition of manure produced from fish fed commonly used feed formulas, to enhance the existing database on the quality of fish manure. This will assist with land disposal options and calculations.
- Examine possible, value-added outlets for collected or composted manure (eg. plant fertilizer etc.)
- Examine various methods for reducing electrical consumption at land-based farms through the evaluation of new pump designs and controller technologies.
- Examine opportunities for on-farm electrical generation through the use of solar, wind power, in-stream generation and other forms of co-generation approaches to determine possible areas for cost-savings at land-based farms which are typically 'heavy' energy consumers.

6. Bibliography

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7. Appendix

Appendix I. Summary of Survey Information Collected from 16 Land-based Facilities.

Appendix II. Summary of Legislation and Regulations Pertaining to Aquaculture in Ontario. (Based on Moccia & Bevan 2000, with revision).

Appendix III. List of Internet Sites related to Aquaculture Legislation in Ontario. (Based on Moccia & Bevan 2000, with revisions).

Appendix IV. Photo Gallery of Land-based Aquaculture in Ontario.

Appendix V. Contents of Compact Disk: “Background Publications and Materials”.

Appendix I. Summary of Survey Information Collected from 16 Land-based Facilities.

Type of facility	**Number**	**Percentage**
Egg producer	12	75
Fingerling Producer	15	94
Stocking	11	69
Food Producer	13	81
Recreational Fee-fishing	2	13
Government / Education	2	13
TOTAL	16	100

Species fish raised	**Number**	**Percentage**
Rainbow trout	15	94
Brook trout	4	25
Arctic charr	5	31
Tilapia	1	6
Largemouth bass	4	25
Smallmouth bass	2	13
Brown trout	4	25
Baitfish	1	6
Walleye	2	13
Yellow perch	0	0
Other	5	31
TOTAL	16	100

Water source	**Number**	**Percentage**
Well (artesian / pumped)	9	56
Spring	11	69
Stream / river	4	25
Pit / quarry	0	0
Lake	0	0
Municipal supply	1	6
TOTAL	16	100

Water use	**Number**	**Percentage**
Single pass	11	69
Reuse (physical treatment)	12	75
Recirculation (biofiltration)	4	25
TOTAL	16	100

Water discharge	**Number**	**Percentage**
Stream / river	14	88
Pit / quarry	1	6
Lake / pond	0	0
Well	0	0
Lake	0	0
Wet-land	1	6
Municipal supply	1	6
No off-site discharge	1	6
TOTAL	16	100

Rearing facilities	**Number**	**Percentage**
Hatchery troughs / tanks	15	94
Circular tanks	11	69
Raceways	15	94
Unlined ponds	5	31
Lined ponds	0	0
Other	1	6
TOTAL	16	100

Feeding methods	**Number**	**Percentage**
Hand feeding	11	69
Demand / pendulum	9	556
Automatic feeders	8	50
Computerized feeding	1	6
TOTAL	16	100

Waste treatment methods	Number	Percentage
Clarifier	6	38
Settling ponds	6	38
Settling within rearing units (with baffles)	2	13
Settling within rearing units (without baffles)	7	44
Swirl separators – gravity	1	6
Swirl separators – mechanical	0	0
Micro-strainer	3	19
Biological filtration	1	6
Other (bacterial digestion)	1	6
TOTAL	16	100

Cleaning methods	Number	Percentage
Flush (stand-pipe pull)	8	50
Brush	5	31
Vacuum	11	69
High pressure washer	0	0
Other (municipal sewage line)	1	6
TOTAL	16	100

Cleaning frequency	Number	Percentage
Continual	4	25
Daily	7	44
Weekly	12	75
Monthly	2	13
Annual	2	13
Other	0	0
TOTAL	16	100

Waste disposal methods	Number	Percentage
On-site – land	13	81
On-site – pit	1	6
Off-site – land	1	6
Off-site – municipal sewer	1	6
Other	0	0
TOTAL	16	100

Appendix II. Summary of Legislation and Regulations Pertaining to Aquaculture in Ontario. (Based on Moccia & Bevan 2000, with revisions.)

A. PROVINCIAL GOVERNMENT AGENCIES	Summary of Principle	Permit(s)
Ontario Ministry of Natural Resources		
Fish and Wildlife Conservation Act	Provide management, perpetuation & rehabilitation of wildlife.	a,b,c,d
+ Ontario Fishery Regulations		
The Lakes and Rivers Improvement Act	Ensure that alterations to water flow do not pose a hazard.	e,f
The Conservation Authorities Act	Preservation of habitat lying within established flood plains.	
Beds of Navigable Waters Act	A lake-bed lease is required by cage culture operations.	
Public Lands Act .	Provides controlled use of public land, and cage culture areas.	g
Aggregate Resources Act	Regulates aggregate removal from water courses.	
Fish Inspection Act	Inspection of products. Ensure product safety and quality.	
Ontario Ministry of the Environment		
Ontario Water Resources Act	Management of surface and groundwater quality and quantity.	h,i,j
Environmental Protection Act	Provide protection & conservation of the natural environment.	k,l
Pesticides Act	Control the availability and use of pesticides.	m
Environmental Assessment Act	Allows environmental assessment to be carried out.	
Conservation Authority		
The Conservation Authorities Act	Controls development within flood plains (see OMNR).	
Ontario Ministry of Municipal Affairs and Housing and local Municipality		
The Planning Act	Allow orderly planning and development of land use.	
Provincial Municipal Act	Bylaws established by local government to regulate land use etc.	n,o
The Niagara Escarpment Planning and Development Act	Additional control of development in this area.	
Ontario Ministry of Agriculture, Food and Rural Affairs		
The Drainage Act	Controls drainage of land, including the discharge of surface water.	
The Nutrient Management Act	Regulates drug use	
The Veterinarians Act		
Ontario Ministry of Labour		
Occupational Health and Safety Act	Protects workers against health and safety hazards	
Ontario Ministry of Transportation		
Highways Act	Wells and structures next to highways	p
Ontario Ministry of Consumer and Commercial Relations	Company registration and/or incorporation	

B. FEDERAL GOVERNMENT AGENCIES	Summary of Principle	Permit(s)
Fisheries and Oceans Canada		
Fisheries Act of Canada	Protection of fisheries and their habitat. Import/export of fish.	q
+ Fish Health Protection Regulations	Regulates movement of certain fish species throughout Canada.	
+ Ontario Fishery Regulations		
Fish Inspection Act and Regulations	Any work or structure placed in navigable water requires approval.	r
Navigable Waters Protection Act		
Agriculture and Agri-Food Canada		
Health of Animals Act	Import and registration of biologics and fish vaccines.	
Feeds Act	Regulates feed quality and drugs in feed.	
Fish Inspection Act and Regulations	Inspection of products for export. Ensure product safety and quality.	
Health Canada		
Food and Drugs Act.	Approval of drugs used in animals, including fish and smoked fish products.	
Pest Control Products Act	Registration of pesticides.	
Environment Canada		
Canadian Environmental Assessment Act	Integrates environmental factors into planning process.	
Canadian Environmental Protection Act	Provides protection and conservation of the natural environment.	
Fisheries Act of Canada (section 36)	Water quality protection of Canadian fisheries waters.	
Migratory Birds Convention Act	Protection of certain bird species.	s
Canada Customs and Revenue Agency		
Goods and Services Act	Consumption tax.	

Permits or Licences Required:

a. *Aquaculture Licence*.
b. *Fish Stocking Licence*.
c. *Licence to Collect Fish from Ontario Waters*.
d. *Bait-fish Dealers Licence*.
e. Application for approval of project's location required. Subsequently, detailed plans and specifications to be submitted.
f. *Permit for Construction, Fill or Alteration of a Watercourse* required for any construction or fill placed in a flood plain or for alteration of a water course.
g. A *Licence of Occupation of Public Land* or *Crown Land Lease* is required if river or lake bottom owned by the Crown.
h. *Permit to Take Water* required if more than 50,000 litres/day (approximately 10,000 Igpd) taken.
i. A "*Certificate of Approval*" is required for construction of any treatment works.
j. Well construction permit required by all water well contractors.
k. A "*Certificate of Approval*" for Organic Waste Management System and Site required for off-property disposal.
l. A "*Certificate of Approval*" is required for stationary combustion engines (e.g. generators).
m. A *Permit to Purchase and/or Perform a Water Extermination* must be obtained before any pesticide is applied to surface waters.
n. *Building Permit* required for any construction work exceeding 100 square feet.
o. Additional permits required for electricity, plumbing, heating, fire etc.
p. Permit required by property owner prior to construction of a well near to a Kings Highway.
q. *Import Permit* required to transfer cultured salmonids and eggs from wild fish between provinces.
r. A *Declaration of Exemption* is required by cage culture operations.
s. *Scare Permit* or *Damage-Kill Permit* may be issued by Canadian Wildlife Service to deter herons.

Appendix III. List of Internet Sites Related to Aquaculture Legislation in Ontario. (Based on Moccia and Bevan 2000, with revisions.)

Name of Agency / Ministry	Internet Address	Comments
Provincial Government:		
Government of Ontario	http://www.gov.on.ca	Home Page
	http://www.gov.on.ca/MBS/english/publications/statregs/index.html	Ontario Acts & regulations online
Ont. Min. Agric. Food & Rural Affairs	http://www.gov.on.ca/OMAFRA/	Home Page
Ont. Min. Environment	http://www.ene.gov.on.ca/	Home Page
Ont. Min. Natural Resources	http://www.mnr.gov.on.ca/MNR	Home Page
Conservation Authority	http://www.grandriver.on.ca/ontario_ca.html	Websites and email addresses
Federal Government:		
Government of Canada	http://canada.gc.ca	Home Page
	http://canada.justice.gc.ca	Links to Acts & regulations
Agriculture & Agri-Food Canada	http://www.agr.ca/lawse.html	See also Canadian Food Inspection Agency
Environment Canada	http://www.ec.gc.ca/legis_e.html	Publications - Legislation
	http://www.ec.gc.ca/water/index.htm	Water policy and legislation
Fisheries & Oceans Canada	http://www.ncr.dfo.ca	Home Page
	http://www.dfo-mpo.gc.ca/communic/policy/dnload_e.html	Acts, orders & regulations
Health Canada	http://www.hc-sc.gc.ca/english/policy.htm	Regulation & policy information
Canada Customs and Revenue Agency	http://www.ccra-adrc.gc.ca	Was Revenue Canada. Gives GST details
Canadian Food Inspection Agency	http://www.cfia-acia.agr.ca/english/actsregs/listacts.html	Overseas a large number of Acts & regulations
Pest Management Regulatory Agency	http://www.hc-sc.gc.ca/pmra-arla	Home Page
Other Links:		
University of Guelph	http://www.aps.uoguelph.ca/~aquacentre/ABM/ABM.htm	Aquaculture Centre “links page”
University of Purdue, USA	http://ag.ansc.purdue.edu/aquanic/jsa/Aquadrugs/Publications/index.html	U.S. Joint Sub-committee on Aquaculture
	http://ag.ansc.purdue.edu/aquanic/publicat/govagen/usda/gdvp.htm	Guide to Drug, Vaccine, and Pesticide Use in Aquaculture

Appendix IV. Photo Gallery of Land-based Aquaculture in Ontario.

1. Sources of ground water and surface water can range from less than 150 litres per minute to over 15,000 litres per minute. Accurate measurement of flow-rates can be a difficult.

Small spring sources of ground water occur frequently.

Large springs can supply several thousand litres per minute of high quality water.

Stream and rivers provide large flow rates, but with less security than ground water sources.

2. A wide variety of land-based aquaculture facilities types and sizes exist in Ontario. Small pond-stocking and recreational fee-fishing operations have limited feed inputs and usually require minimal waste management control.

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Small earthern ponds used to rear rainbow trout.

Recreational fee-fishing operations are numerous.

A series of small raceways showing solids settling zone at discharge end.

3. Larger hatcheries and food-production facilities typically use concrete tanks and raceways to rear trout and charr.

Circular tanks used to raise trout and charr. Overhead covers provide shade and predator protection.

Concrete raceways provide a cost efficient rearing system that can be build in many configurations. Within-tank settling zones allows for solids collection.

4. Quiet settling zones within raceways, or dedicated clarifiers provide a simple method to remove settleable solids from the discharge water.

Small clarifier system constructed from pre-cast concrete septic tanks.

Clarifier tank allows sufficient time for suspended solids to settle out and form a layer of sludge on the bottom of the tank.

Settled solids are concentrated by decanting the clear upper water. The remaining sludge is transferred to either a liquid manure tanker or stored off-line during the winter period.

5. Aquaculture sludge provides a source of plant macro and micronutrients that are spread on adjacent land. Careful control of application rate and other criteria ensures that nutrients remain within the soil and do not enter ground or surface waters.

Ariel view showing polishing ponds for removal of fine settleable solids and adjacent property for land application of collected solids (liquid manure).

Liquid manure is land applied using a vacuum sprayer or injected into the soil.

Appendix V. Contents of Compact Disk: "Background Publications"

1. Aquaculture Centre

AARS Manure composition
Aquaculture Legislation
Aquaculture Manure Composition
Aquastats 1988
Aquastats 1995
Aquastats 1996
Aquastats 1997
Aquastats 1998
Aquastats 1999
Aquastats 2000
Aquastats 2001
Aquastats 2003
Can fish suffer – review article 2004
Fish & Omega-3 Fatty Acids
OARSCC Priorities 2003

2. Ont. Min. Agriculture

NMA 2002 (Bill 81)
NMA Compendium (2001)
Nutrient Management Planning – overview
NMA 2002 Terminology
NMA 2002 Small livestock
NMA 2002 New and Expanding Farms

3. Ont. Min. Environment

MOE Map of Offices
MOE Map of regional areas
MOE Watershed Management
MOE Environmental Protection
MOE Groundwater Studies
MOE Effluent Requirement
MOE Guidelines for CofA
MOE Application for CofA
MOE Guide to application cost for CofA
MOE Guidelines for updating CofA
MOE Guide for PTTW
MOE Application for PTTW
MOE Review Process for PTTW
MOE Proposed Amendment to PTTW
MOE PTTW Manual Draft

4. Ont. Min. Natural Resources

Fish and Wildlife Conservation Act (1997)
OMNR Aquatic Introductions
OMNR Low Water Response
OMNR Watershed Management Plan
Ontario Secondary Watersheds

5. Other Canadian Sources

CAIA Situational Analysis of Aquaculture Industry
Stats Canada – Canadian Aquaculture 2002
DFO National Code on Intro. and Transfers of Aquatic Organisms
North American Aquaculture – Net Results 2001
OCAD Report 2003
OCAD Report 2004
Ont. Env. Comm. Report (2000-1)
Ont. Farm Safety Association Newsletter
Ont. map of Conservation Authority Watersheds
Property Rights in Canadian Aquaculture
Value and economic Impact of Freshwater Aquaculture in Canada (GREPA)

6. Other Sources

Australia Aquaculture Effluent Manual
Best Management Practice – USA Flow through aquaculture
Effluent management at the farm level
Effluent treatment in flow-through systems – Europe
Fish Welfare Report 2002 (In too deep)
Fisheries Society – fish welfare
Particulate removal from raceways – USA
Recirculation – reduced environmental impact
USDA – EPA Effluent Guidelines
USDA Effluent Guidelines (factsheet)