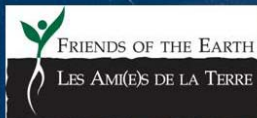




A Study of Freshwater Aquaculture in Canada

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**WATER SOFT PATH PROJECT
LED BY
FRIENDS OF THE EARTH CANADA**

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INTRODUCTION

The constraints of fresh water use in aquaculture have been well recognized at a global level, and have been widely addressed at the practical local level, in planning new developments, managing water use in existing operations, and in an increasing number of cases, re-engineering production units to improve efficiency of water use. These changes are driven not just by a greater appreciation and concern for responsible resource use, but by the very real cost pressures associated with water abstraction and waste discharge.

An increase in demand for freshwater fishes and concern over expansion of a relatively new industry has put the focus on aquaculture in Canada.

The Department of Fisheries and Oceans (DFO) defines aquaculture as "the farming of aquatic organisms in marine or freshwater. It implies some form of intervention in the rearing or growing process to enhance production, such as regular stocking, feeding, and/or protection from predators and disease. It also implies individual or corporate ownership of the stock or crop being farmed." (DFO, 2005).

The Food and Agriculture Organization (FAO) of the United Nations (UN) defines aquaculture as "the farming of aquatic organisms including fish, mollusks, crustaceans and aquatic plants with some sort of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Farming also implies individual or corporate ownership of the stock being cultivated." (FAO, 2005).

There are five main ways in which fish can be farmed: 1. Cage (fixed, floating, submersible, submerged). 2. Closed water systems. 3. Pond (often less than one hectare). 4. Raceways. 5. Inland aquaculture farms.

In cage aquaculture, fish are raised in large cages floating in water outdoors. A large amount of fish can be raised in cage aquaculture without incurring high facility fees. Some farmers use net pens within their cages, which provide easy access to the fish. Cage-reared rainbow trout accounts for most of the freshwater aquaculture production in central Canada.

Raceways are artificial water channels through which water is continuously pumped (or is flowing). The cost of raceways is quite high; along with water fees, large amounts of effluent, including nutrient discharge, must be disposed of properly (Alberta, 2001).

AQUACULTURE PRODUCTION

The main freshwater fish farmed in Canada are Arctic Char, Tilapia, Rainbow Trout and Brook Trout (AAFC, 2003). Specifically, Rainbow Trout and Tilapia in Alberta; Rainbow Trout, Brook Trout, Arctic Char and Tilapia in Ontario; and Arctic Char, Tilapia and Rainbow Trout in Nova Scotia. On average, it takes a production cycle of up to 12 months to produce a half kilogram fish.

Aquaculture provides jobs for more than 7,000 Canadians, and in 2003, accounted for more than 14% of the total Canadian production offish and shellfish (AAFC 2003).

The total amount of aquaculture production in Canada in 2003 was 155 634 tonnes, worth \$585.5 million

dollars.

Due to reasons of confidentiality Alberta's totals are not reported, but are estimated to be just over 3% of the total value of aquaculture in Canada¹. The year 2000 performance of the Alberta aquaculture industry has been estimated at \$10.8 million (AB Government, 2001).

Ontario produced 4650 tonnes of trout, or 2.9% of the total value of aquaculture in Canada.

Nova Scotia produced 4.8% of the total aquaculture production in Canada in 2003 (finfish accounting for 3.3%), amounting to 6.6 % of the total value of aquaculture in Canada (where finfish accounts for = 4.6%)².

Currently Rainbow Trout accounts for 95% of aquaculture production in Ontario (Aquaculture Centre, 2005). This is primarily due to legislative restrictions on farmed fish. The Game and Fish Act of Ontario was changed in 1997 to allow more (over three dozen) species to be farmed in Ontario.

According to the Nova Scotia Department of Agriculture and Fisheries, just over 4 metric tonnes of Rainbow Trout were farmed for "U-Fish" farms in 2004, valued at \$43 041. The Department does not distinguish between Atlantic Salmon and freshwater Rainbow Trout (and other fish, including Tilapia and Arctic Char); the total amount produced in 2004 was 23.2 metric tonnes, valued at \$5.45 Million (NS Government, 2004).

WATER SUPPLY

Aquaculture is not a net user of water; all water that flows through the aquaculture operations is eventually returned to a receiving watercourse.

Water supply for fish farms comes from both groundwater and surface water; these sources include springs, wells, and diversions from natural watercourses such as streams, rivers or lakes, or municipal water. Minimal pumping, if any, is required for spring water, and as such is advantageous over other water sources. Diverted (surface) water, however, is often used due to ease of availability.

Temperature is also an important variable when deciding which water source(s) to use; salmon prefer groundwater (from springs and wells) due to its disease-free, uniform water quality as compared to surface water. Rainbow trout breed ideally at temperatures higher than that of groundwater (15°C), while arctic char prefer colder water. Tilapia is a warm-water fish, and requires water temperatures between 25

¹ Alberta produced 2109 tonnes valued at \$17 652M in 2003, as calculated by subtraction of the rest of the provinces and territories from the Canadian total.

² Finfish include salmon and steelhead, which are not exclusively freshwater fish.

to 30°C. Something to keep in mind is the large temperature fluctuations of surface water - high in the summer, and very low during winter, as well as water quality fluctuations (Moccia, 1997).

WATER QUANTITY

The modern, environmentally accepted method of aquaculture production is recirculation. Most of the water source is circulated back into the system for reuse. Any effluent waste can easily be managed. These systems require considerable capital investment and have high operating costs. Rearing fish can be done year-round (Alberta, 2001).

Constant water flow is used to renew oxygen supply and remove waste product. There are three main inflows into an aquaculture operation: precipitation, runoff and regulated water additions. Main outflows are through evaporation, seepage, overflow after storms and intentional discharge. Stream inflow, unless it is the main source of water, transpiration and consumptive use are rarely major factors (Boyd, 2000).

Rainbow trout can be raised in tanks, raceways or ponds.

Most farms operate with water supplies between 36 Lpm (litres per minute) and 45 000 Lpm (Moccia, 1997). This amounts to between 52 000 and 64.8 million litres of water per day, or between 18.9 million to 23.6 billion litres of water per year, per aquaculture farm.

It is generally accepted that a minimum rate of 13 gallons per minute (gpm) [49 Lpm] is required for each surface acre of ponds. Large ponds require much water to be replaced due to evaporation and seepage water losses. It is also necessary to fill ponds quickly during the spawning season. In raceway aquaculture, it is advisable to have a minimum flow rate of 500 gpm [117 Lpm]. Water recirculating systems that recycle water may require large quantities of water depending on the size of the operation. For example, if a 100,000-gallon [378 litre] capacity water recirculating operation exchanges 10 percent of the water daily, it will require 10,000 gallons [37 854 litres] of water per day (Swann, 1997).

There are very few studies or aquaculture farms which report water use figures. In Ontario, the Grand River Conservation Authority produced an article about water use in the Grand River watershed (southwest of Toronto). According to their numbers, aquaculture uses 5%, or 16 million cubic metres³, of water per year in the Grand River watershed. (In comparison, Agriculture and Farm Irrigation uses 6%). It is the sixth largest water use in the watershed, and this figure includes water used for large-scale fish farms or public fishing ponds, which require a continuous stream of fresh water (GRCA, 2004).

Water conservation in pond aquaculture can be achieved through several methods, including evaporation control, seepage control and water management. Evaporation control includes control of aquatic weeds and deepening ponds to reduce surface area to volume ratio, though this is not very practical as ponds should rarely be over 2m deep. Seepage can be a major water loss from ponds; it is important to consider both embankments and bottoms, and construct them accordingly (install clay cores in dams, compact well-graded soils in pond bottoms or use clay layers to retard seepage). It is also important to provide

³ This data was obtained through information provided by the government of Ontario through their Permits To Take Water. Recall that a PTTW is necessary for amounts greater than 50000L/day; this is approximately the amount of water flowing from a good garden hose all day.

storage volume for rain falling into ponds as a water conservation measure. Water exchange is of little benefit to water quality; water reuse conserves water, often lowers costs and reduces the volume of pond effluents.

The New Hampshire Department of Environmental Services has put out a fact sheet on water efficiency practices in aquaculture. Since large volumes of water are required to maintain aquaculture systems, water efficiency practices are important to reduce the demands on source water. These include:

1. Minimum flow rates (enough to maintain temperature, dissolved oxygen and dissolved concentrated solids).
2. Mechanisms to control and measure flow throughout the aquaculture system (e.g. sealed weir boards, pipe valves, sharp crested weirs and flow metres).
3. Reduce the amount of water used in cleaning; use pressurized culture water with physical scrubbing for cleaning when water necessary; sweep or shovel if possible.
4. Routine leak checks and maintenance, along with tank and pipe upgrades when necessary.
5. Water circulation (from early stage to later stage tanks) and recirculation (e.g. using a swirl separator - a cone shaped tank and whirlpool - fish wastes are eliminated through the bottom while aerating the water).
6. Minimize flow required for fish (while keeping adequate dissolved oxygen levels).
7. Use of different treatment methods to remove dissolved solids and reduce nitrate, nitrite and ammonia to be able to recycle water (e.g. gas strippers; screens; particulate, membrane, carbon, bio- and sand filters; ion-exchange systems; UV/ozone systems)
8. Use drought-resistant, native plants for landscaping (NHDES, 2001).

QUALITY

There are many ways that freshwater can be affected through aquaculture. Current fish farming practices include problems with sewage (fish excrement and uneaten feed) and drug or nutrient loading (antibiotics, pesticides, feed additives, paint and disinfectants) into surrounding waters and soil (DSF, 2005).

The byproducts of fish metabolism include carbon dioxide, ammonia and fecal solids; if uneaten feed and these byproducts are left untreated, they will reduce the oxygen content of water, and generate more carbon dioxide and total ammonia-nitrogen (TAN). Current Canadian guidelines do not address mass nutrient loading in relation to assimilative capacity of receiving waters.

A broad range of chemicals is used globally, though only a small group is licensed in Canada. Four antibiotic drugs (oxytetracycline, florfenicol, sulfadimethoxine plus ormetoprim, sulfadiazine plus trimethoprim), one anaesthetic (tricaine methanesulphonate) and two fungicides/disinfectants (formaldehyde and hydrogen peroxide) are approved to be used in fish food in Canada (Scott, 2005).

Environment Canada (EC) has a Municipal Water Use Database, while Statistics Canada has an Industrial Water Use Survey Database, though both concentrate on the manufacturing sector and there are no specific amounts attributed to aquaculture.

In particular, it is believed that organic wastes from cage farms may contribute to increased nutrient concentrations, increased algae growth, and reduced oxygen concentrations in fresh waters.

CONCLUSION

Though pond aquaculture is more water intensive than most other methods of food production, the value of the end product produced per unit water used is higher for aquaculture than for other crops (Boyd, 2000).

Research is needed on the fate and effect of therapeutants in freshwater systems.

Bio-Aqua technology is a system of treating and recirculating water specifically for aquaculture. It was developed with funding from the National Research Council of Canada, Canada Economic Development and the Ministry of Environment of Quebec. It relies on bioprocessing and a robot for continuous cleaning, while recycling 90% of the water. A rotating screen removes solids, while bioprocessing, degassing and ozone systems are also in place. With this system in place, biochemical oxygen demand (BOD), nitrogen and phosphorus in the effluent are reduced by 95%, while total suspended solids (TSS) are reduced by close to 90%; in continuous operation, it is reported that these figures remain constant on a daily basis (Environment Canada, 2004).

Statistics Canada is publishing a 2004 Survey of the Aquaculture Industry (which will include expenses such as purchased water) in fall 2005⁴.

An experiment to identify and quantify environmental impacts of freshwater (rainbow trout) cage aquaculture on a lake ecosystem in northwestern Ontario is underway. Fisheries and Oceans Canada is leading this project, which has been extended for another four years - two more for fish production, followed by two years to look at "recovery" once farming operations cease.

⁴ For survey assistance: 1.888.881.3666.

APPENDIX A: AQUACULTURE LEGISLATION IN CANADA

There is no federal aquaculture act or any aquaculture regulations in Canada; aquaculture is the shared responsibility of the federal government and its provincial and territorial counterparts.

The federal role involves areas such as research, development, inter-provincial and export trade, and environmental sustainability including water quality studies. The Department of Fisheries and Oceans (DFO) is the lead federal department for aquaculture, though in total there are 17 federal departments and agencies that deliver programs and services to the aquaculture industry. Agriculture and Agri-Food Canada, Health Canada and Environment Canada all play a role in aquaculture.

Sections 34, 35 and 36 of the Fisheries Act prohibit the harmful alteration, disruption or destruction (HADD) of fish habitat and prohibit the deposition of deleterious substances. Canadian Coast Guard approval is required for an aquaculture facility under section 5 of the Navigable Waters Protection Act (NWPA) if it is located in navigable waters. Approval of aquaculture tenures under NWPA or HADD may trigger an environmental assessment under the Canadian Environmental Assessment Act."

The provinces and territories have the responsibility for the majority of site approvals and for overseeing the industry's day-to-day operations. Changes to aquaculture operations require amendments to existing permits or granting of new or additional permits.

Memoranda of Understanding (MOUs) have been signed between the federal government and British Columbia, Quebec, New Brunswick, Nova Scotia (July 1995), Prince Edward Island, Newfoundland and Labrador, Yukon and the Northwest Territories. These MOUs meet the needs of the aquaculture industry in each province/territory and set out the specific federal and provincial/territorial responsibilities (DFO, 2005).

The Canadian Council of Fisheries and Aquaculture Ministers (CCFAM) established an Aquaculture Task Group (ATG) in 1999, composed of federal and provincial representatives, to ensure collaboration between the various levels of government. The ATG acts as a steering committee with the goal of establishing the direction for aquaculture development in Canada and creating environmentally sustainable and economically viable opportunities for the aquaculture sector through cooperation.

The Department of Fisheries and Oceans (DFO) also established the Interdepartmental Committee on Aquaculture (ICA) to improve federal interdepartmental collaboration in the area of aquaculture development.

The Office of the Commissioner for Aquaculture Development (defunct as of March 31, 2004) Aquaculture Policy Framework: In May 2002, Fisheries and Oceans Canada released its Aquaculture Policy Framework. The policy is the Department's response to the 1995 Federal Aquaculture Development Strategy, and emphasizes DFO's commitment to both sustainable aquaculture policy and global aquaculture competitiveness. Though the OCAD no longer exists, in 2000 DFO established and still operates a Program for Sustainable Aquaculture.

The Standing Committee on Fisheries and Oceans undertook a study on aquaculture in Canada from 2000-2002. It examined the role of the federal government, the regulatory environment and the potential environmental and ecological challenges posed by an expanded aquaculture industry. Aquaculture legislation was among their many recommendations. (Wappel 2003).

Water management is a provincial responsibility; many of the implementing agencies and organizations are local or regional agencies. Contrary to parts of Ontario, where many responsibilities, such as planning,

program implementation, flood control, and public education and awareness, are often undertaken by watershed organizations (e.g., Grand River Conservation Authority), watershed management in Alberta is occurs on a piecemeal basis. For instance, watershed management is undertaken by a number of agencies including local municipalities, the Oldman River Intermunicipal Service Agency (provides planning services for the communities in the watershed), irrigation districts, and regional interests, such as the South Saskatchewan River Sub Basin Advisory Committee (examining and making recommendations for water allocation and transfers within southern Alberta).

In addition to agencies with local or regional legislated authority, other organizations, such as the Oldman River Water Quality Initiative, aim to improve water quality within the basin by offering information and programs related to best management practices for agriculture and rural residents, through the promotion of water conservation, and provision of land use and environmental information (Rush, 2003).

APPENDIX B: AQUACULTURE LEGISLATION IN ALBERTA

Alberta

As with all provinces, the production and marketing of fresh-water fish in Alberta comply with both federal and provincial regulations. Alberta regulates possession of live cultured fish in the province through legislation maintained by the Fisheries Management Division at Alberta Sustainable Resource Development.

Only certain species of fish are eligible for to be raised through aquaculture: Arctic char, Brook trout, Brown trout, Rainbow trout, Tiger trout, Grass carp, Atlantic salmon, Chinook salmon, Coho salmon, Sockeye/Kokanee salmon, Freshwater prawns, Goldfish, Koi and Tilapia. Alberta Agriculture, Food and Rural Development's Aquaculture Section, issues three types of fish licences.

Under Section 8 of the Alberta Fisheries Act, these licenses are required to acquire, grow, breed, keep and sell live cultured fish in Alberta. The regulations also specify that aquaculture can only take place within "contained waters" or "prescribed waters." Contained waters refer to: aquariums/tanks normally housed within a building or man-made reservoirs (dugouts) that have their water effectively isolated from flowing into another water source, are lined with an impervious material and no larger than 600 square feet in surface area. Prescribed waters are: water bodies or contained waters that have their source of water as a municipal water supply, a well or through surface runoff; or water bodies that are completely surrounded by private land, or other land that is not public land under the Public Lands Act. With the exception of some provincially run fish hatcheries, aquaculture operations aren't currently permitted on public land (Alberta, 2004).

Cage culture is not allowed in Alberta's public waters, unless it is approved through a research permit from Alberta Sustainable Resource Development's Fisheries Management Division (Alberta, 2001).

A diversion or use of water licence may be required from Alberta Environment to use large volumes of surface or groundwater. Nutrient limits are also set for effluent management. Any commercial operation discharging effluent must conform to those limits.

APPENDIX C: AQUACULTURE LEGISLATION IN ONTARIO

Ontario

The Ontario Ministry of Natural Resources administers several licenses under the Fish and Wildlife Conservation Act of Ontario, which replaced the Game and Fish Act January 1, 1999. All fish farms require an Aquaculture Licence, granted by the Ontario Ministry of Natural Resources, to culture and sell fish, and some require a license to stock, purchase and transport fish in Ontario. The licence is valid for five (5) years (Moccia, 2000).

The Ontario Ministry of Environment and Energy is in charge of Permits To Take Water, under Section 34 of the Ontario Water Resources Act, for amounts exceeding 50 OOL per day (Ontario, 2005); this is approximately 35 L/minute, which is similar to leaving a garden hose flowing all day. A Licence to Stock Fish in Ontario Waters (valid for three years) may also be necessary if fish are being stocked in ponds connected to open water, and fee fishing on private property requires a Fishing Preserve Licence. Over 200 private-sector fish production facilities exist in Ontario (Moccia, 1997).

A Certificate of Approval, which is granted if the Application for the Approval of Plans and Specifications for the Construction of Works for the Collection, Transmission, Treatment and Discharge of Industrial Wastewater is approved, is required by most industrial facilities that discharge water.

The Ontario provincial government (Ontario Ministry of Agriculture and Food) has been in a partnership with the University of Guelph in aquaculture research. Since 1990, the Aquaculture Centre at the University of Guelph has coordinated a variety of research, extension and educational activities. It produces 'Aquastats', a report of aquaculture production in Ontario. The latest Aquastats available on the web is from 2001; Statistics Canada provides more current reports.

The Grand River Conservation Authority is one of Ontario's largest watershed-based agencies. It has a mandate, under the Conservation Authorities Act, to manage natural resources and regulate surface water flows. As such, it plays a key role in local water management.

APPENDIX D: AQUACULTURE LEGISLATION IN NOVA SCOTIA

Nova Scotia

The Department of Agriculture and Fisheries is in charge of aquaculture in Nova Scotia. According to the Aquaculture Association of Nova Scotia, every new farm application and license renewal must undergo an Environmental Assessment, and each farm must have in place an Environmental Monitoring Plan.

The fee for Water Withdrawal Approval is waived for aquaculture, and the fee for fish farming or a fish hatchery operation is 20 percent. (Nova Scotia, April 2004)

According to the Fisheries and Coastal Resources Act of Nova Scotia, an aquaculture licence is necessary to carry out commercial aquaculture. It is also necessary to procure an aquaculture lease if the farm is on Crown land. The licence is valid for a maximum of ten years, with a right to renewal for further terms of five years. It gives possession of the water column and sub-aquatic land, and is issued for a specific geographic area and specific species to be farmed.

Before issuing a licence, the Minister consults with the Department of Agriculture and Marketing, the Department of the Environment, the Department of Housing and Municipal Affairs and the Department of Natural Resources, and any boards, agencies and commissions as necessary. The application may be sent to a private sector, regional aquaculture development advisory committee for comment and recommendation. The application may be referred to a public hearing if it is not approved automatically (Nova Scotia, 2001).

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