Freshwater fish in Ontario's boreal: Status, conservation and potential impacts of development

A Wildlife Conservation Society Canada Conservation Report

Executive Summary

Freshwater ecosystems are among the most threatened ecosystems on the planet. Physical alteration, water withdrawal, overexploitation, pollution, and the introduction of non-native species have caused widespread habitat loss, degradation in water quality, declines in the abundance of aquatic animals, and biodiversity loss. More than 20 percent of the world's 10,000 freshwater fish species have become threatened, endangered or extinct in recent decades.

In Ontario, the area north of the current limit for forestry activities (roughly straddling the 51st parallel) is one of the largest swaths of largely undisturbed boreal forest in Canada. This landscape is characterized as much by the network of lakes, rivers, swamps, and bogs that make up a large part of the surface area as it is by the coniferous forest expanses that the region is more commonly known for.

In fact, the lakes and rivers of northern Ontario are part of the single largest area of high fish biodiversity that has experienced the least human alteration of the natural landscape in Canada. Five of the 12 remaining undammed and unregulated watersheds in North America south of 55 degrees occur in northern Ontario, which also contains the third largest wetland on the planet -- the Hudson Bay Lowlands, covering 25% of Ontario's land surface.

Unlike in more developed regions in southern Ontario, fish communities of the northern part of the province remain largely unaltered by species introductions, stocking, overexploitation, or pollution. In fact, the current intact condition of fisheries in this region provides a virtually unprecedented opportunity to conserve fish communities in their original abundance and diversity -- a challenge that will require proactive land use planning and information gathering to be successful.

These freshwater ecosystems also have great cultural and economic importance: Approximately 10,000 people live in remote First Nations communities situated on the lakes and rivers of far northern Ontario with the water courses serving as the highways of the region in summer and winter and residents relying on plentiful walleye and whitefish populations as a major food source.

The high concentration of lakes containing walleye and northern pike in the region has also made it a top destination for fly-in sport fishing. The resource-based tourism industry is a major component of the northern Ontario economy. The total annual economic activity from resource-based tourism for all of northern Ontario is approximately $306 million with remote fly-in operations accounting for 25% of the tourism businesses in the region.

At the same time, the natural resources of far northern Ontario offer significant potential for economic development and commercial exploitation. The development of these resources – hydroelectricity, forestry, and mineral -- is now of growing interest to industry, First Nations and the province This northern boreal landscape is therefore both an ecological gem, as yet largely unaffected by industrial development, and a likely target for much greater development pressures in the near future.

Due to recent efforts to plan for increased economic development in the region, such as the Northern Boreal Initiative, scientists, resource managers, and conservationists have begun to identify priorities for conservation of the unique flora and fauna of the area. To date, these efforts have largely focused on terrestrial mammals, with a particular emphasis on wide-ranging terrestrial mammals native to the region, such as woodland caribou.

And while general life history and status information on northern boreal fisheries is available, one of the key impediments to ecosystem-based planning in the region is the profound lack of comprehensive baseline information on most species that have a demonstrated vulnerability to the land-use changes being contemplated. In the case of the region's fish species, very little information exists on their distribution, abundance, life history, and the history of harvesting or other impacts. Additionally, much of the knowledge about the region's fish communities lies with local residents and those involved in sport fisheries, such as remote tourism operators. As a consequence, fish are rarely given sufficient consideration in land use or resource planning initiatives.

This report represents a first step in expanding the dialogue on Boreal conservation to include aquatic ecosystems. The objectives of this report are to:

I. present information on the region's fish species with a particular focus on those of high economic or cultural importance;
II. review what is known and what remains unknown regarding the effects of various types of resource development activities on freshwater environments and fish; and
III. offer policy and research recommendations toward the enhancement of freshwater fish conservation and management in the region.

Freshwater Fishes of Northern Ontario

The freshwater environments of northern Ontario can be divided into two major ecozones: the Boreal Shield zone and the Hudson Plains. The Boreal Shield is underlain by the bedrock of the Precambrian Canadian Shield and important fish habitat extends across its matrix of lake, river, and wetland habitats. The Hudson Bay lowlands are also dominated by freshwater, although because most of the thousands of bogs and ponds that dot the landscape are shallow and freeze to the bottom in winter, fish diversity is mostly concentrated in the streams and rivers that dissect the area.

Fifty-three species of fish in 15 families occur in the region making it one of the more diverse regions of Canada. The distribution of 11 of these species is limited to the southern edge of the area or along the Hudson Bay coast, while 42 species are widely distributed throughout the lakes and rivers of the roadless portion of northern Ontario. Together, this

diversity of fish species creates a mosaic of different fish communities distributed among the thousands of ponds, lakes, streams and rivers of northern Ontario.

At a regional scale, this diversity can be summarized into community types based on which top predator species are present in the environment. Three communities types -- Walleye/Northern Pike, Lake trout/Whitefish/Cisco, and Brook trout – are profiled in this report, with descriptions of their distribution, ecology, life history, and current conservation status. Lake sturgeon – a species that migrates through rivers and lakes -- is an additional focus here due to its status as a threatened species throughout much of North America.

Walleye and northern pike occur in most lakes and rivers of the region with most populations in a relatively unharvested, pristine state. The slow-growing northern walleye and pike populations are more vulnerable to overexploitation than their counterparts to the south, with populations in the north likely less able to withstand the increased exploitation that may accompany increased access due to their slower maturation in environments characterized by shorter growing seasons.

Small tributary streams and rivers throughout the area host abundant brook trout populations. Sea-run brook trout are also common in the rivers draining into Hudson and James Bay. Lake trout, a coldwater species inhabiting deep lakes with limited nutrients, are relatively rare in the northern region. Meanwhile, lake trout are in decline in southern Ontario, largely due to species introductions, eutrophication and fishing pressure..

Lake sturgeon occur in all of the major rivers of northern Ontario and, given the plight of most populations in the south, these may be the last populations remaining in the province that have not yet been affected by intensive human harvesting and habitat alteration. Lake sturgeon populations require large unfragmented watersheds to thrive, due to their lifetime migratory patterns. This is why populations located downstream from dams have, in particular, experienced negative impacts.

<u>Impacts of forestry, hydroelectric development, mining, and roads on fish populations</u>

The combined potential for forestry, hydroelectricity, and mineral extraction in the northern boreal region may represent a major economic opportunity for the province of Ontario. All three types of development, however, also affect aquatic ecosystems and fish thanks to a variety of associated impacts, including increased sedimentation in waterways, changes in water flow, habitat fragmentation, release of pollutants, and increased access for recreational fishing.

Forestry results in two major changes to the landscape that affect aquatic habitats:

- Forest removal alters groundwater flow and surface runoff, which can lead to the release of mercury, nutrients, dissolved organic carbon, and sediment to adjacent water bodies.
- Logging roads may result in fragmented (artificially divided) aquatic habitat due to poorly constructed water crossings, increased sedimentation due to the erosion of roads, and increased human exploitation of fish populations as a result of easier "drive in" access to lakes and rivers.

Clearcutting of boreal forest has been linked to increases in mercury concentrations in fish such as walleye and pike. This linkage is particularly strong in relatively flat landscapes with poor drainage and extensive wetland areas – the kind of landscape found in much of northern Ontario. Forest removal commonly leads to an influx of nutrients, minerals, and organic matter to lakes and rivers with significant differences between the effects of forest loss due to fire versus logging. Fire, for example, does not disturb soils or lead to the creation of roads and water crossings. Logging may also increase total runoff and change the flow regime of forest streams, thereby altering the physical stream habitat, species distributions and productivity.

Stream crossings (bridges and culverts) – of which there may be hundreds of thousands along the tens of thousands of kilometers of forestry roads in Ontario --- have been shown to cause significant fragmentation of aquatic habitats. Such crossings can, for example, block upstream movement by fish, thereby causing habitat disconnections or fragmentation.

In the watersheds of the boreal forest of northern Ontario, species likely to be adversely affected by barriers in small streams include brook trout, white sucker, minnows, and darters. In large streams and rivers, species likely to be affected by poorly constructed water crossings include lake sturgeon, walleye, and brook trout.

While certain impacts may be mitigated by "best practices" and regulations -- such as reducing sedimentation by leaving vegetated buffer strips around water bodies or minimizing barriers to fish movement by building appropriate water crossings -- other impacts are more difficult to mitigate, such as the accumulation of mercury in surface waters of logged watersheds or increased human access due to logging road networks. Overall, the consequences of all such changes to aquatic environments for fish habitats and communities vary from minimal to severe, and most remain poorly understood.

Hydroelectric dams alter river systems in three primary ways:

- Reservoir creation: The creation of a reservoir above the dam has two main fisheries impacts: the loss of river habitat, and the release of mercury from the flooded land into the river ecosystem.
- Barriers to fish movement: Blocking the upstream and downstream movement of species affects populations in a number of ways: it blocks upstream migration to spawning grounds, prevents downstream migration of juveniles to rearing areas, prevents seasonal movement between winter and summer habitats, and isolates populations.
- Alteration of flow regime: Alteration of the magnitude, frequency, duration, timing, and rate of water flow below the dam has a wide variety of impacts on downstream aquatic systems, including changes in sediment accumulation or scouring of the river bed, and reduced spawning success through the loss or degradation of spawning habitat.

Northern Ontario contains a number of large rivers whose combined hydroelectric potential is over 4000 megawatts. Many of these sites are too distant from transmission lines to make development viable in the near future; however, two sites on the Albany River and several

sites on the already highly developed Mattagami, Abitibi, and Moose rivers have been proposed for future development.

Hydroelectric dams result in long-term impacts to river ecosystems. In Ontario, lake sturgeon and brook trout are particularly sensitive to the effects of habitat fragmentation and changes in water flow caused by dams. River-spawning populations of cisco and lake whitefish from Hudson and James Bay may also be affected by hydroelectric development. The effects on walleye and pike appear to be mixed with some populations increasing and others suffering declines. For lake sturgeon, it is unclear whether populations can survive following dam construction: In the Moose River watershed, where dam construction occurred 40 to 60 years ago, many lake sturgeon populations appear to be in decline.

A second important effect of hydroelectric development is the associated increase in mercury concentrations of commonly consumed fish such as walleye. For remote northern community residents who rely on fish for a significant portion of their diet, the effects of increased mercury exposure are a serious concern.

Mining operations can adversely affect the aquatic environment in several ways:

- Release of mine effluent into lakes and rivers in the form of water pumped from the mine or used for processing the ore;
- Storage of resulting waste rock and processing waste, referred to as mine tailings, in piles or ponds on the mine site where precipitation and processing waste water leaches metals and other contaminants into adjacent surface water and groundwater;
- Physical alteration or destruction of aquatic habitat resulting from mine construction and operation in areas with abundant surface waters;
- Increased access to surrounding lakes and rivers through the construction of roads to the mining site.

Compared to forestry or hydroelectric development, mining has the potential for much greater acute and chronic environmental impacts when toxic contaminants are released into the environment. In northern Ontario, gold will likely continue to be the most common type of mineral being mined and the continued use of cyanide in the extraction of the gold will continue to pose a threat to aquatic ecosystems.

Mining operations also commonly leave behind large amounts of contaminated ore and acid generating rock, which both pose a long-term threat to aquatic biota. Monitoring and maintenance of waste-containment systems (e.g. tailings ponds) in remote northern locations will pose an important challenge to those monitoring the impacts of mining on remote northern ecosystems.

Meanwhile, Canadian law requires that aquatic habitat destruction caused by mine construction be mitigated by the creation of equivalent habitat. However, after 20 years of implementation there are insufficient data to determine if this has been an effective approach to preventing negative impacts on fish populations. Likewise, it is too early to determine if the new regulations and monitoring programs will reduce the future impacts of mines on aquatic ecosystems.

New road networks can have a number of negative impacts on fish populations:

- "drive in" recreational fishing may lead to overharvesting and declining fish populations;
- stocking may be used to increase angler success with potential impacts on native populations (increased competition, introduction of non-native species, etc.); and
- increased access may reduce the economic viability of "fly in" or other remote fishing operations that rely on limited access to high-value fisheries.

All types of resource operations commonly lead to increased access to previously remote areas through new road construction. The network of primary, secondary and tertiary roads created during logging operations has the most widespread impact, but roads for other types of operations (mines, hydro facilities) may have dramatic local or regional impacts.

The status of sport fish populations across the province of Ontario ranges from collapsed to pristine, with three factors driving this gradient: ease of access; distance from human settlements; and regional population density. As road networks expand and human populations increase, the extent to which remoteness will serve to maintain quality fishing opportunities -- defined as fish populations with large mean size and high catch rates per unit of effort -- will decline. This reduction in fishing quality, i.e., smaller fish, lower catch rates or both, can take anywhere from years to decades in a given area depending on fish population size, fishing intensity, and the reproductive capacity of the species.

The likely outcome of increased access to lakes and rivers in northern Ontario can be surmised from looking at the status of sport fisheries in the south. In general, increased fishing pressure will lead to declines in the abundance and mean size of walleye, northern pike, lake trout, brook trout, and lake sturgeon. Development in previously roadless areas may therefore indirectly result in a loss of abundant fish populations and world class sport fisheries that are an important source of income for communities across the north.

Mapping current impacts

The health of freshwater ecosystems is largely determined by the presence and intensity of human impacts, including resource extraction, land transformation, human settlement, and industrial development.

In order to gauge the current threat to northern freshwater environments, we created a province-wide map of cumulative impacts on watersheds. We also mapped cumulative impacts for a larger number of factors specifically for northern watersheds.

The maps highlight the current low level of watershed impacts north of the managed forest boundary in Ontario, particularly compared to what has happened in the industrially allocated southern regions. They also help us identify northern watersheds where increased development may also have a major impact on freshwater ecosystems south of the boundary.

Climate change

An additional overarching threat to freshwater ecosystems in the boreal region is global climate change. Significant climatic changes, including warming and decreased precipitation, are expected in northern Ontario over the next 50 to 100 years. Climate change will influence boreal freshwater ecosystems by affecting ice cover, water temperatures, total water volumes, and the water quality of freshwater bodies, with the magnitude of these impacts differing depending on waterbody characteristics.

In particular, fish are directly affected by the temperature of their environment, as it plays a role in the regulation of all of their physiological processes. Therefore, fish species and individual populations will be adversely or positively affected in myriad ways by climate-driven changes to aquatic environments even in the absence of human development.

Recommendations and Information Needs

This report has highlighted a growing body of research that documents the potential for traditional resource-based industries and activities to have a serious negative impact on fish populations in one of the world's most intact areas for freshwater ecosystems.

Mitigation measures and policies meant to address these potential impacts have been subjected to little testing and their effectiveness remains, at best, unclear. Therefore, in the face of the steady northward march of development, we simply cannot be assured that we have the knowledge and regulatory systems to adequately safeguard globally significant aquatic systems.

Basic research is needed to determine the impact thresholds for various development activities. We currently cannot accurately predict, for example, the risk of mercury accumulation in aquatic ecosystems due to clearcutting or whether lake sturgeon populations can persist following habitat fragmentation caused by dams. Equally seriously, we cannot currently project the potential cumulative impacts on fish populations and habitats as new development projects follow on others.

In fact, we lack even the baseline information on distributions and population status of many fish species across the region that will be needed to monitor the impacts of future development projects, to say nothing of informing current planning processes (while some key attributes of fish community needs are known, much more site and species-specific work needs to be undertaken).

Therefore, our review leads us to the following recommendations:

- Establish a Fisheries Research and Assessment Unit for the area of northern Ontario above the current managed forest boundary;
- Enhance knowledge of the distribution and status of fish in the region, particularly those exhibiting demonstrated vulnerability to development in order to incorporate fish and aquatic considerations into conservation-based planning;

- Avoid piecemeal decisions on development projects by undertaking a comprehensive landscape-level assessment of lake sturgeon, brook trout, lake trout, walleye, and northern pike values north of the managed forest boundary and put in place adequate protection measures *before* development projects are initiated;
- Develop an understanding of the threshold for damaging effects, such as the impact of clearcutting on mercury accumulation in aquatic ecosystems of boreal forest regions, and develop forest management guidelines that will prevent cumulative effects of mercury contamination;
- Determine whether lake sturgeon can persist in dammed rivers, and, if so, the threshold of disturbance populations can tolerate.
- Maintain the current moratorium on hydroelectric development over 25 MW north of the managed forest boundary and undertake a comprehensive landscape-level assessment of lake sturgeon values north of the managed forest boundaries in order to ensure that adequate protection measures are put in place *before* development projects are initiated
- Improve the collection of fish production data prior to mine development to allow for an assessment of the effectiveness of habitat compensation measures.
- Investigate the relationship between logging road development and fishing pressure, including the effect of distance from human settlements and distance between roads and water bodies, to better understand how increased access affects species and populations
- Incorporate knowledge about high-quality fisheries into landscape-scale land use planning in order to identify areas that should be kept roadless and access-free;
- Establish restricted access fisheries in newly logged areas in partnership with anglers, local communities, and tourism operators, and plan road networks to allow for restricted access by constructing easily monitored single entry and exit points.